

CRETACEOUS FAUNAS FROM ZULULAND AND NATAL,
SOUTH AFRICA.

THE AMMONITE FAMILY BACULITIDAE GILL, 1871
(EXCLUDING THE GENUS *EUBACULITES*)

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ABSTRACT

Representatives of the ammonite family Baculitidae are common faunal elements in the mid- and Upper Cretaceous of Zululand. The genus *Lechites* is rare, being represented by a single species in the Upper Albian, *L. gaudini* (Pictet & Campiche); *Sciponoceras* is represented by rare Cenomanian *S. roto* Cieřliński, *S. baculoides* (Mantell) and common *S. cucullatum* Collignon. *Baculites* is very common, and represented by Coniacian *B. yokoyamai* Tokunaga & Shimizu, Coniacian to Santonian *B. capensis* Woods, Coniacian to Campanian *B. bailyi* Woods, and Campanian *B. sulcatus* Baily, *B. increscens* Collignon, *B. vanhoepeni* Venzo, *B. duharti* Hünicken, *Baculites* sp. aff. *B. rectus* Marshall and *B. nibelae* sp. nov.

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INTRODUCTION

Members of the ammonite family Baculitidae are conspicuous faunal elements in the mid- and Upper Cretaceous of Zululand. Early representatives of the family belonging to the genus *Lechites* are rare, and so far only one species, *L. gaudini* (Pictet & Campiche), represented by two specimens, is known from the Upper Albian of Zululand. *Sciponoceras* is locally common in the Cenomanian; the majority of specimens belong to the Lower Cenomanian *S. cucullatum* Collignon. *Sciponoceras roto* Cieřliński and *S. baculoides* (Mantell) are rare in the Lower and Middle Cenomanian, respectively. Turonian sediments are absent in outcrops in Zululand and there is thus no baculitid record of this stage. The earliest Middle Coniacian baculitids include smooth, or

only rarely ribbed forms, referable to *B. yokoyamai* Tokunaga & Shimizu and *B. bailyi* Woods. Nodose baculitids of the group of *B. capensis* Woods first appear in the Middle Coniacian, and become very abundant in the Upper Coniacian of Zululand where they, in places, formed the major part of the biomass. Concretions crowded with *B. capensis* are common in parts of the Middle and Upper Coniacian. *Baculites capensis* and *B. bailyi* are common up to the Lower or the Middle Santonian in southern Africa, but both occur as late as the Early Campanian. Ribbed *B. sulcatus* Baily occurs in the Lower Campanian of Pondoland. In Zululand and Natal, ribbed to nodose baculitids referable to *B. increscens* Collignon, *B. vanhoepeni* Venzo and *B. nibelae* sp. nov. occur in the Lower and Middle, and possibly part of the Upper Campanian, respectively. A smooth species, *B. duharti* Hünicken is recorded from the Middle Campanian.

In the Maastrichtian of Zululand, the genus *Eubaculites* replaces *Baculites* completely, and locally forms a major part of the total biomass. Representatives of the genus *Eubaculites* from Zululand have been described earlier by Klinger (1976) and Klinger & Kennedy (1993) and include *E. carinatus* (Morton), *E. labyrinthicus* (Morton), *E. latecarinatus* (Brunnschweiler) and *E. simplex* (Kossmat).

CLASSIFICATION

Fig. 1

Until recently, authorship of the family Baculitidae was ascribed to Meek (1876) (see e.g. Wright 1957: L218; Luppov & Drushchits 1958: 64). However, the name Baculitidae had been introduced five years earlier by Gill, in 1871, and authorship rests with him, as correctly indicated by Wright (1981: 172).

Wiedmann (1962a: 179) suggested that Cretaceous ptychoceratitid, polyptychoceratid, hamitid and baculitid heteromorphs could be united as subfamilies into a single family, Baculitidae, and later (Wiedmann 1962b: 93) even suggested including bochianitids in this 'super' family Baculitidae. This radical reorganization has found few supporters apart from Scholz (1979). According to a recent review of the higher taxa of Jurassic and Cretaceous Ammonoidea by Besnosov & Michailova (1991), Wiedmann's classification would involve lumping genera of two different orders into a single family! We regard the family Baculitidae as a rather conservative group that probably had its origins in the genus *Hamites* in the Albian, and retained a more or less straight shell throughout its existence right up to the end of the Cretaceous Period.

The earliest baculitid, *Lechites*, arose in the Upper Albian from the genus *Hamites*. The adult shell of *Lechites* consists of a single, straight shaft; as yet, the ammonitella is unknown. Ornament is simple, consisting of circum-peripheral ribs. Constrictions are rare. One small branch of *Lechites*, elevated to subgeneric rank as *L. (Tuberolechites)* by Cooper & Kennedy (1977), developed feeble tubercles on the venter. There is considerable variation in the symmetry of the umbilical lobe in *Lechites* (see e.g. Wiedmann & Dieni 1968: 63, text-fig. 36; Scholz 1979: 14, text-fig. 5A); it may differ on either side of the same individual. Recent comprehensive reviews of the genus by Cooper &

Kennedy (1977) and Scholz (1979) differed somewhat in details, but covered most of the taxonomic problems. The distribution of the genus is more or less cosmopolitan.

Baculites (?) (*Protobaculites*) *ambiguus* Collignon (1964: 9, pl. 319 (fig. 1375)), recorded from a single specimen from the Lower Cenomanian of Madagascar, was regarded by Collignon as a possible precursor of *Baculites*, as indicated by the etymology. Ornament consists of annular ribs and periodic constrictions between every fifth and sixth rib. The suture line has a trifid umbilical (U) lobe and a large internal (I) lobe. Kennedy & Wright (1994) have shown that *Baculites* (?) (*Protobaculites*) *ambiguus* is, in fact, not a baculitid, but a *Hemiptrychoceras*.

Lechites gave rise to the next-oldest baculitid genus, *Sciponoceras*, in the Early Cenomanian. The main feature of *Sciponoceras* is the regular occurrence of constrictions. The last representatives of *Sciponoceras* occur in the Upper Turonian. As in *Lechites*, *Sciponoceras* has a more or less cosmopolitan distribution.

The first true *Baculites* occur in the Lower Turonian and differ from contemporary *Sciponoceras* mainly by the loss of regular constrictions. The earliest, Turonian, *Baculites* are cosmopolitan but later representatives become restricted to distinct biogeographic regions. The genus *Baculites* persists up to the end of the Maastrichtian, and is amongst the last ammonite genera before the extinction of the order Ammonoidea at the K/T boundary (see e.g. Birkelund 1979, 1993; Ward & Kennedy 1993).

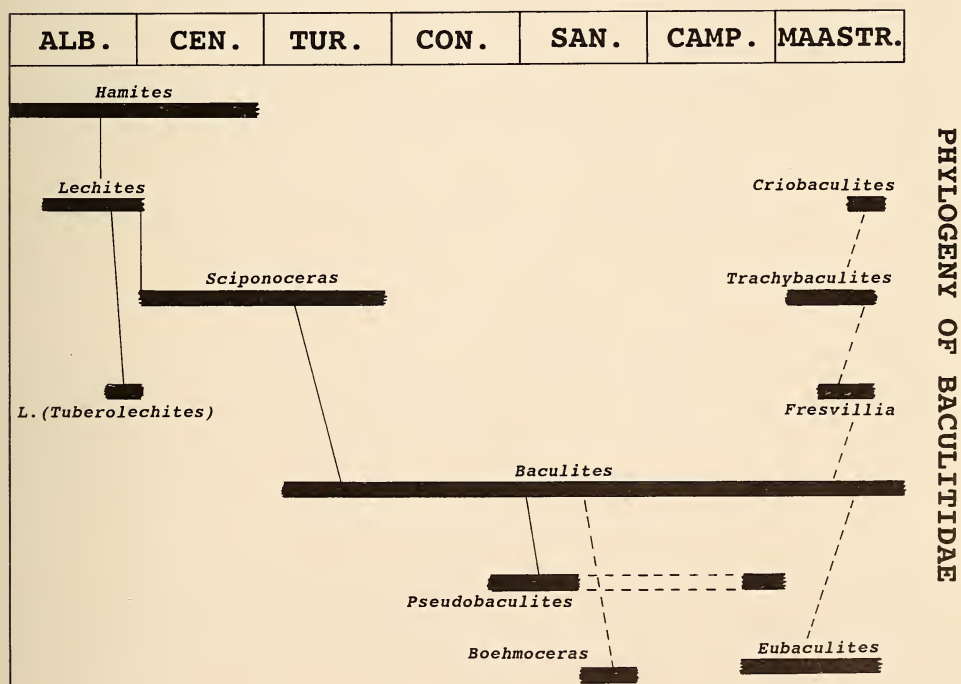


Fig. 1. Suggested phylogeny of the ammonite family Baculitidae Gill, 1871.
Time axis not to scale.

During the Late Coniacian, an insignificant baculitid lineage, *Pseudobaculites*, arose from *Baculites* in the United States Western Interior. It differed from contemporary *Baculites* mainly in being larger, having a more rapid rate of taper, and a far more complex suture line. *Pseudobaculites* is an endemic lineage, the last representatives occurring in the Lower Maastrichtian; no representatives are known outside the U.S. Western Interior.

Boehmoceras, another short-lived but apparently slightly more widely distributed lineage, evolved from *Baculites* during the Late Santonian. The shell is coiled in an open criocone, and it is interpreted as a recoiled baculitid. It is so far known only from the Upper Santonian of Germany, Sweden, Austria, France, Mississippi, Alabama and Texas; it is rare in Europe, but common in the Gulf Coast region of the U.S.A.

During the Late Campanian, the genus *Eubaculites* arose from *Baculites*, differing from the latter mainly by the development of a tabulate or acute venter and pyriform whorl section. *Eubaculites* is the dominant baculitid of the Maastrichtian in the Southern Hemisphere, excluding Antarctica and New Zealand. It is rare in Western Europe, and absent or not yet recorded from the Middle East and North and West Africa. It is also absent from the U.S. Western Interior, but occurs in the Pacific, Gulf Coast and Atlantic Seaboard regions of the U.S.A.

A number of aberrant baculitids are known from the Maastrichtian but their origins and relations to *Baculites* are not clear. They all probably merit generic separation and include:

(1) *Fresvillia* Kennedy, 1986, type species *Fresvillia constricta* Kennedy, 1986a (p. 62, pl. 14 (figs 39–42), text-fig. 10a) from the Upper Maastrichtian of France. Also included in the genus is *Baculites teres* Forbes, 1846 (p. 115, pl. 10 (fig. 5)), recorded from the Upper Maastrichtian of Southern India and tentatively from the Maastrichtian of California (Matsumoto 1959: 163, pl. 45 (figs 5a–d, 6a–c), text-figs 82a–c, 83) and southern Alaska (Jones 1963: 29, pl. 16 (figs 10–12, 14), text-fig. 14).

(2) *Trachybaculites* Cobban & Kennedy, 1995, type species *Baculites columna* Morton, 1834 (p. 44, pl. 19 (fig. 8)) (see Cobban & Kennedy 1992c, 1995) from the Maastrichtian of Alabama, Texas, Mississippi, California and South Dakota. This is a heterochronous homoeomorph of Albian *Lechites* with circumperipheral ribbing, but with apparently simplified sutures.

Baculites lechitides Brunnschweiler, 1966 (p. 23, pl. 1 (figs 1–3), text-fig. 8) from the Upper Maastrichtian of Western Australia probably also belongs here and possibly *B. kegei* Oliveira (1957: 22, pl. 2 (figs 6–7), text-fig. 1) from the Maastrichtian of Brazil. According to Cobban & Kennedy (1995: 29), *Baculites vicentiei* Stinnesbeck, 1986 (p. 203, pl. 9 (fig. 4), pl. 10 (figs 3–6), text-figs 23a–c) from the Maastrichtian of Chile also belongs to *Trachybaculites*.

(3) The group of *Hamites trabeatus* Morton, 1834 (p. 45, pl. 15 (fig. 3)) from the Upper Maastrichtian of Alabama, appears to be an endogastrically recoiled baculitid lineage, homoeomorphic with Santonian *Boehmoceras* but for the position of the siphuncle. *Baculites?* sp. of Cobban & Kennedy (1992c: 68, figs 1.1–1.4, 3.1) from the Maastrichtian Fox Hills Formation of South Dakota belongs here.

The name *Criobaculites* gen. nov. is here proposed for this group, with type species *Hamites trabeatus* Morton, 1834. **Diagnosis:** Criocone coiled baculitids with siphuncle inside the curve (i.e. endogastric).

(4) ?The group of *Baculites paradoxus* Pervinqui re, 1907 (p. 94, pl. 4 (figs 10–11), text-fig. 24) from the Upper Maastrichtian of Tunisia. We are not certain if this group belongs to the family Baculitidae at all. These are minute, straight shells with trigonal saddles and lobes, reminiscent of some *Sciponoceras*. *Baculites* ind t. of Pervinqui re (1907: 95, pl. 4 (fig. 12a–b), text-fig. 25) may also belong here. It differs from *B. paradoxus* mainly in possession of constrictions. Both are of very dubious baculitid affinities and are better regarded as allied to *Phylloptychoceras*.

LOCATION OF SPECIMENS

The following abbreviations are used to indicate the repositories of material referred to in the text.

SAM	South African Museum, Cape Town
NMB	National Museum, Bloemfontein—presently housed in the South African Museum
TM	Transvaal Museum, Pretoria
MRC	Prof. M. R. Cooper Collection, University of Durban-Westville
SAS	Geological Survey, Pretoria—presently housed in the South African Museum
GD	Institut des Sciences de la Terre de l'Universit� Dijon (ex Collignon Collection)
BMNH	The Natural History Museum, London
MNHP	Mus�um National d'Histoire Naturelle, Paris
CPC	Facultad de Ciencias Exactas, F�sicas y Naturales, Universidad Nacional de C�rdoba, Argentina
GO	Department of Geological Sciences, University of Bologna

FIELD LOCALITIES

Details of field localities are given in Kennedy & Klinger (1975); fuller descriptions of localities are deposited in the Department of Palaeontology, Natural History Museum, London, Geological Survey of South Africa, Pretoria, and Division of Earth Sciences, South African Museum, Cape Town. Additional localities are referred to in the text.

DIMENSIONS

All dimensions are given in millimetres. MxWb—maximum whorl breadth (in mm); MxWh—maximum whorl height (in mm); MnWb—minimum whorl breadth (in mm); MnWh—minimum whorl height (in mm); D—distance between maximum and minimum whorl height and breadth measurements (in mm); Wb/Wh—ratio of whorl breadth to whorl height; Ri—Rib or tubercle index:

number of ribs or tubercles per whorl height; Ti—taper index (after Matsumoto & Obata 1963: 4) ($Ti = MxWh - MnWh / D \times 100$).

SUTURE TERMINOLOGY

The suture terminology of Wedekind (1916) reviewed and discussed by Kullmann & Wiedmann (1970) is followed here: I = internal lobe, U = umbilical lobe, L = lateral lobe, E = external lobe.

SYSTEMATIC PALAEONTOLOGY

Class CEPHALOPODA Cuvier, 1797

Order AMMONOIDEA Zittel, 1884

Suborder ANCYLOCERATINA Wiedmann, 1960

Family **Baculitidae** Gill, 1871

Genus *Lechites* Nowak, 1908

Type species. *Baculites gaudini* Pictet & Campiche (1861: 112, pl. 55 (figs 5–9)) by the original designation of Nowak (1908: 350).

Diagnosis

Shell straight, with simple ornament consisting of prorsiradiate ribs, sometimes grouped in pairs; shallow constrictions may be present. Ventral tubercles present in some. Dimorphic; macroconchs with trumpet-shaped aperture, microconch with down-turned aperture and incipient lappets.

Discussion

Lechites is the oldest of the Baculitidae; it first appeared in the Late Albian and, as Spath (1941: 660) had previously suggested, was presumably derived from *Hamites*. Middle Albian records, as *Baculites Sanctae-Crucis* Pictet & Campiche (1861: 109, pl. 55 (figs 1–4)) are probably misidentified protanisceratids and not *Lechites* (see e.g. Spath 1939: 572–573; 1941: 661 footnote).

Recent work by Cooper & Kennedy (1977) and Scholz (1979) showed that some specimens of *Lechites* in the Upper Albian and Lower Cenomanian acquire incipient to distinct ventral tubercles, and are homoeomorphs of *Idiohamites* and *Pseudoxybeloceras* fragments to a certain extent. Cooper & Kennedy (1977) separated the tuberculate forms as a separate subgenus of *Lechites*, *Tuberolechites* (type species *Tuberolechites regifex* Cooper & Kennedy, 1977: 654, fig. 8 (1–15)). Initially Scholz also considered separating them at least at subgeneric level. On closer examination, Scholz (1979: 15) found that all transitions occur between simply ribbed *L. gaudini* and tuberculate forms in the condensed sequences he studied. According to Scholz, the tuberculate forms occur in the Upper Albian and again in the 'Vraconnian'; he thus regarded the acquisition of tubercles as an iterative, rather than as a unique monophyletic event. Consequently, Scholz merely separated tuberculate and normally ribbed at subspecific level, as *Lechites gaudini* s.s. and *L. gaudini nodosus* Scholz (1979: 15, pl. 1 (figs 11–16)).

It is important to note that, in spite of their unique morphology, tuberculate forms of *Lechites* are rare. Cooper & Kennedy (1977: 645, 654) examined nearly 200 specimens of *L. gaudini* but found only four tuberculate examples; Scholz (1979: 12, 15) had nearly 700 specimens of *L. gaudini*, of which only 32 from France and nine from Hungary were tuberculate.

From the extensive descriptions of e.g. Spath (1941), Renz (1968), Cooper & Kennedy (1977) and Scholz (1979), it is obvious that there is considerable variation in the shape and density of ribbing, and that transitions occur between most of the different 'species' attributed to the genus. A reduction in the number of names, as suggested by Cooper & Kennedy (1977) and Scholz (1979), is probably justifiable.

Occurrence

Lechites is known with confidence only from the Upper Albian. It has been recorded from Western and Central Europe, North Africa, ?Somalia, Madagascar, Zululand, India, North, Central and South America, Antarctica (Thomson 1984: 88—as *Baculites*; Moncrieff & Kelly 1993: 5) and Japan (Hokkaido).

Lechites gaudini (Pictet & Campiche, 1861)

Figs 2A–C, M, 3

- 1861 *Baculites Gaudini* Pictet & Campiche, p. 112, pl. 55 (figs 5–9).
- 1933 *Baculites Gaudini* Pictet & Campiche; Collignon, p. 73, pl. 5 (fig. 8, 8a).
- non 1936 *Baculites Gaudini* Pictet & Campiche; Vanzo, p. 118 [60], pl. 10 [6] (fig. 3).
[= *Sciponoceras ?cucullatum*]
- 1941 *Lechites gaudini* (Pictet & Campiche); Spath, p. 662, pl. 72 (figs 4–7, 9–10), text-fig. 242. (*cum. synon.*)
- 1941 *Lechites communis* Spath, p. 666, text-fig. 244.
- 1947 *Lechites Gaudini* var. *raricosta* Breistroffer, p. 78.
- ? 1968 *Lechites italicus* Wiedmann & Dieni, p. 64, pl. 6 (fig. 10), text-fig. 37.
- 1968 *Lechites campichei* Renz, p. 82, pl. 17 (figs 8a–c, 9a–c, 10a–b), text-fig. 29m.
- 1968 *Lechites vraconensis* Renz, p. 82, pl. 17 (figs 11a–c, 12a–b, 14a–b, 15a–c), text-fig. 29b, g–h, k.
- ? 1971 *Lechites fasciata* Scholz, p. 431, figs 1–2.
- 1977 *Lechites gaudini* (Pictet & Campiche); Cooper & Kennedy, p. 644, figs 1 (1–38), 2 (1–30), 3, 4 (1–18), 5 (1–15), 6–7, 8 (16–26). (*cum. synon.*)
- 1978 *Lechites gaudini* (Pictet & Camp.); Scholz, pl. 3 (figs 1, 8).
- 1979 *Lechites gaudini gaudini* (Pictet & Campiche); Scholz, p. 12, pl. 1 (figs 1–9), text-fig. 5A–B.
- 1982 *Lechites* aff. *gaudini* Pictet & Campiche; Renz, p. 59, pl. 20 (fig. 7a–b).
- 1983 *Lechites gaudini* (Pict. & Camp.); Horvath, pl. 1 (fig. 2).
- 1984 *Lechites gaudini* (Pict. & Camp.); Mitiu, p. 83, pl. 2 (figs 6–9).
- 1984 *Lechites gaudini* (Pict. & Camp.) transition to *L. communis* Spath; Mitiu, p. 85, pl. 2 (figs 10–11).
- 1984 *Lechites communis* Spath; Mitiu, p. 85, pl. 2 (figs 12–13).
- 1985 *Lechites gaudini* (Pictet & Campiche); Immel & Seyed-Emami, p. 112, pl. 7 (fig. 11).
- 1991 *Lechites communis* (Pictet & Campiche); Ivanov, pl. 4 (fig. 11).

Type

Lectotype, by subsequent designation of Spath (1941, p. 663) the specimen figured by Pictet & Campiche (1861, pl. 55 (fig. 5a–c)) and refigured by Renz

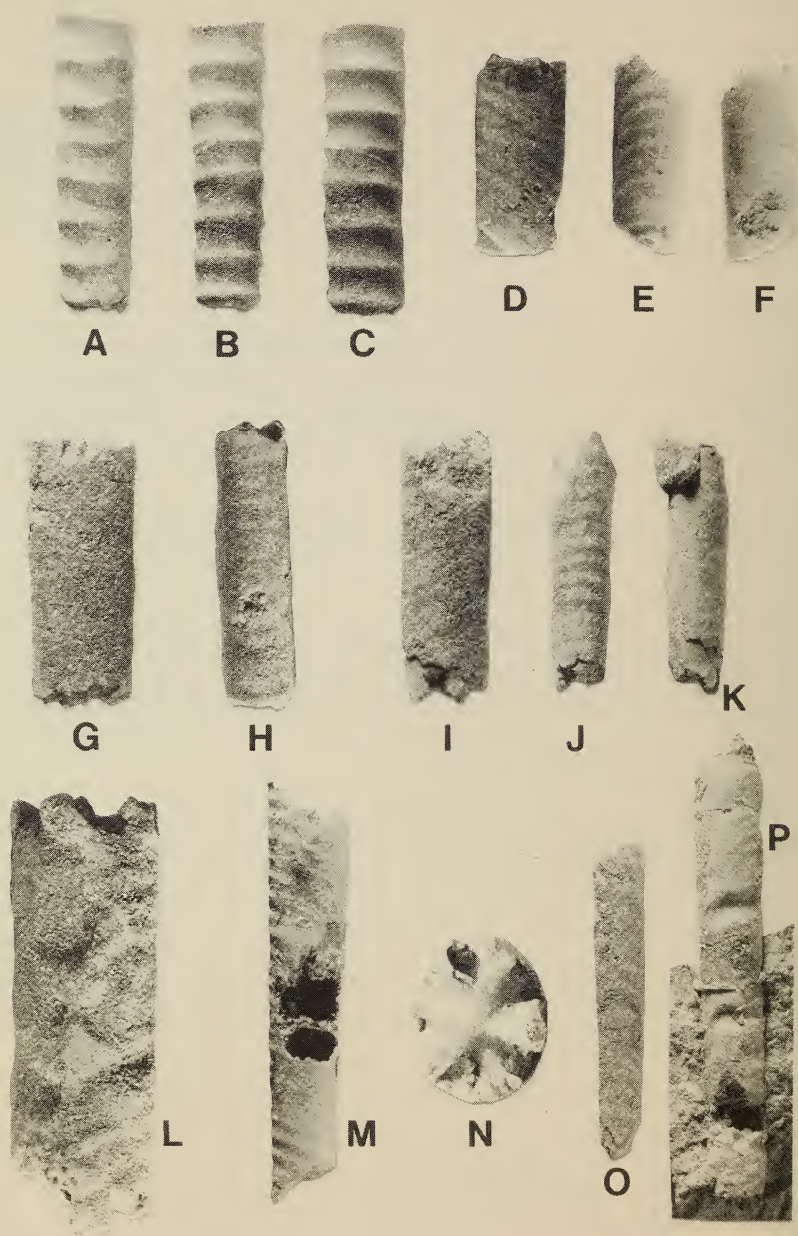


Fig. 2

(1968, pl. 17 (fig. 3)) from the Upper Albian *Stoliczkaia dispar* zone of Sainte-Croix, Kanton Waadt, Switzerland.

Material

SAM-PCZ8766 from locality 182, Zululand, Mzinene Formation. Outcrops here extend from uppermost Albian to Lower Cenomanian; SAS Z19 from Haughton's (1936: 299) locality Z19 on the Pongola River, north of the confluence with the Mfongozi Creek, Zululand, Mzinene Formation, Upper Albian.

Description

SAM-PCZ8766 is part of a phragmocone with parts of the original shell preserved; SAS Z19 is an internal mould of part of the body chamber with the last septum preserved. The whorl section in both specimens is ovoid, higher than wide with Wb : Wh ratios $7.7 : 8.8 = 0.87$ and $7.8 : 10.2 = 0.76$, respectively. PCZ8766 is finely ribbed, with 5 ribs per whorl height; Z19 is more coarsely ribbed with 3 ribs per whorl height.

The suture is partially exposed in PCZ8766 (Fig. 3); the umbilical lobe (U) is distinctly smaller than the lateral lobe (L) and asymmetric.

Discussion

Lechites gaudini is quite variable as far as density and shape of ribbing is concerned, and several varietal or specific names have been given to extreme morphologies. PCZ8766 could be referred to *Lechites gaudini* s.s., whereas Z19 could be referred to *L. raricosta* Breistroffer, 1947. We follow Cooper & Kennedy (1977: 644), Wiedmann & Dieni (1968: 62) and Scholz (1979: 12) in including these variants within *L. gaudini* s.s. *Lechites antanimangaensis* Collignon (1964: 34, pl. 325 (fig. 1451)) is very similar to our coarsely ribbed specimen (Z19). However, it has been suggested by Cooper & Kennedy (1977: 653) and Wright & Kennedy (1995: 314) that *L. antanimangaensis* may be a *Sciponoceras* body chamber.

Occurrence

The species is common in the Upper Albian, *Stoliczkaia dispar* zone. It has been recorded from England, France, Switzerland, Romania, Hungary, Sardinia, Algeria, Madagascar, southern India, Hokkaido, Mexico, Venezuela and Antarctica.

Fig. 2 (see facing page). A-C, *M. Lechites gaudini* (Pictet & Campiche, 1861). A-C. SAS Z19 from Haughton's (1936: 299) locality Z19, Zululand, Mzinene Formation, Albian. M. SAM-PCZ8766 from locality 182, Mzinene Formation; the locality ranges from the Upper Albian to Lower Cenomanian I. D-F. *Sciponoceras baculoides* (Mantell, 1822). SAS A705 from an unspecified horizon on the Skoenberg, Mzinene Formation, Cenomanian. G-L, N-O. *Sciponoceras cucullatum* Collignon (1964). G-H. NMB D1004a. I-K. SAS H210/34. L, N. NMB D1004b. O. NMB D1002a. All from an unspecified horizon on the Skoenberg, Mzinene Formation, Cenomanian. P. *Sciponoceras roto* Cieřliński, 1959. SAS EM191 from an unspecified horizon at locality 181, Zululand, Mzinene Formation, Cenomanian I or II. All $\times 1$.

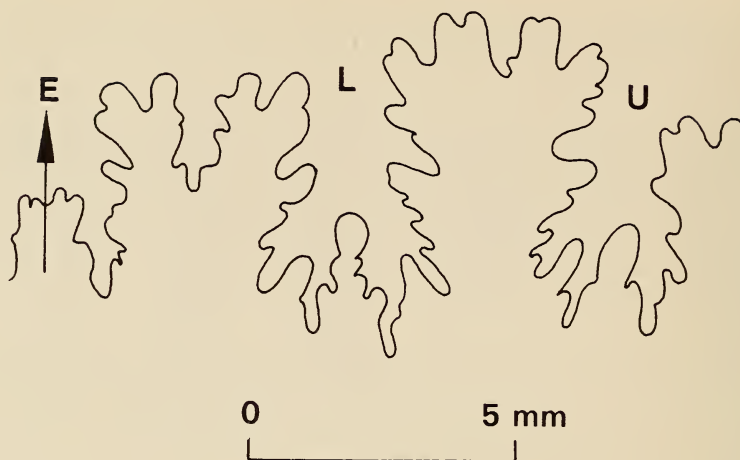


Fig. 3. *Lechites gaudini* (Pictet & Campiche, 1861).
Suture line of SAM-PCZ8766. Scale bar for size.

Genus *Sciponoceras* Hyatt, 1894

(= *Cyrtochilus* Meek, 1876, *non* Jakowlew, 1875; *Cyrtochilella* Strand, 1929)

Type species: Hamites baculoides Mantell, 1822: 123, pl. 23 (figs 6–7), by the original designation of Hyatt (1894: 578).

Diagnosis

According to the most comprehensive, recent review by Wright & Kennedy (1981: 112), '*Sciponoceras* is distinguished . . . by its marked constrictions. These are straight and prorsiradiate in early forms but in later ones are rursiradiate on the inner quarter or third of the flank and then turn forward. There are also well-marked, weakly branching ribs on the body chamber or the whole shell, following the same course as the constrictions. The apertural features appear to be of specific as well as sexual significance; some are relatively simple, others have a long rostrum, broad folds and a high collar, others have long lateral lappets.'

Discussion

Extensive discussions on *Sciponoceras* are given by Matsumoto (1959), Matsumoto & Obata (1963), Kennedy (1971), Cobban & Scott (1972), Wright (1979), Wright & Kennedy (1981), Kennedy & Juignet (1983) and Wright & Kennedy (1995), and nothing new can be added to these.

Occurrence

Transitions from *Lechites* to *Sciponoceras* first occur in the Upper Albian *Stoliczkaia dispar* Zone faunas of the Anglo-Paris Basin. The genus extends to the Upper Turonian. The genus has a world-wide distribution (see Matsumoto

1973: 422, fig. 1), including Europe as far east as Transcaspia, the Middle East, North Africa, Madagascar, Zululand, ?Angola, India, northern Australia, New Zealand, various localities in North America in the Western Interior, Gulf Coast and California, Mexico, and in Argentina in South America.

Sciponoceras baculoides (Mantell, 1822)

Fig. 2D-F

- 1822 *Hamites baculoides* Mantell, p. 123, pl. 23 (figs 6-7).
 1959 *Sciponoceras baculoide* (Mantell); Matsumoto, p. 104, pl. 31 (fig. 1a-d), text-fig. 2a-b. (*cum. synonym.*)
 non 1973 *Sciponoceras baculoide* (Mantell); Henderson, p. 81, text-fig. 4a-d, fig. 6 nos 4a-c, 5a-c, 7a-c.
 ? 1975 *Sciponoceras baculoides* (Mantell); Förster, p. 166, pl. 4 (fig. 6), text-fig. 36.
 1980 *Sciponoceras baculoide* (Mantell); Marcinowski, p. 252, pl. 3 (figs 17-20).
 1983 *Sciponoceras baculoides* (Mantell); Kennedy & Juignet, p. 19, figs 11(a)-(y), 12(a)-(bb), 13(a)-(w), 14(a)-(n) (*cum. synonym.*)
 1983 *Sciponoceras baculoide* (Mantell); Marcinowski & Walaszczyk, pl. 1 (fig. 3).
 1983 *Sciponoceras baculoide* (Mantell); Kaplan *et al.* pl. 5 (fig. 2).
 1987 *Sciponoceras baculoides* (Mantell); Wright & Kennedy, p. 177, pl. 37 (fig. 13).
 1991 *Sciponoceras baculoide* (Mantell); Delamette & Kennedy, p. 462, figs 17.6, 17.7, 17.14, 17.15.
 1992 *Sciponoceras baculoide* (Mantell); Thomel, pl. 6 (fig. 7), pl. 10 (fig. 2), pl. 11 (figs 1-3), pl. 19 (fig. 4).
 1995 *Sciponoceras baculoides* (Mantell); Wright & Kennedy, p. 317, pl. 95 (figs 1-3, 5-10), pl. 96 (figs 1-7), pl. 97 (figs 1-5), pl. 98 (figs 29-32), text-figs 129H, 132R-S, 133A-C, M-FF. (*cum. synonym.*)

Type

Lectotype BMNH 8612, by subsequent designation of Kennedy (1971: 9), is the larger specimen on the block figured by Mantell (1822, pl. 23 (fig. 6)) from the lower Middle Cenomanian of Hamsey, Sussex, refigured by Kennedy (1971, pl. 2 (fig. 5a-b)).

Material

SAS A705 from an unspecified horizon and locality on the Skoenberg, Zululand, Mzinene Formation, Cenomanian.

Description

The specimen is a phragmocone fragment, preserved as an internal mould in glauconitic silt. Part of a constriction is preserved at the smaller end, and faint prorsiradiate ribs are visible on the flanks and over the venter. The whorl section is ovoid, Wb : Wh 10.7 : 11.7 (= 0.91).

Discussion

Extensive descriptions and discussions can be found in Kennedy (1971), Juignet & Kennedy (1976), Kennedy & Juignet (1983) and Wright & Kennedy (1995).

Occurrence

Sciponoceras baculoides has been reported from the Lower to Upper Cenomanian, but many of these records are difficult to substantiate. According to Kennedy & Juignet (1983: 22), the species is abundant only in the lower part of the Middle Cenomanian in southern England and France. It extends to the lower Upper Cenomanian. Other records are from Germany, Poland, Romania, California, North Africa, southern India, Madagascar, Mozambique and Zululand.

Sciponoceras cucullatum Collignon, 1964

Figs 2G-L, N-O, 4-5, 6A-D

- ? 1936 *Baculites Gaudini* Pictet & Campiche; Venzo, p. 118 [60], pl. 10 [6] (fig. 3).
1964 *Sciponoceras cucullatum* Collignon, p. 38, pl. 326 (fig. 1458).

Type

Holotype by monotypy is the specimen figured by Collignon (1964, pl. 326 (fig. 1458)) from the 'Lower' Cenomanian, Zone of *Mantelliceras mantelli* and *Calycoceras newboldi* of gisement 505, west of the falls of Mahaboboka (Manera), Madagascar; herein refigured in Figure 6A-C.

Material

SAM-PCZ7499, PCZ9137, PCZ9139-9140, NMB D1002, D1002a-b, D1003a-c, D1004, D1004a-i, SAS H210/23, H30-31, H33-35, SAS A106, 1063-1064, 1069, all from an imprecisely located horizon on the Skoenberg at locality 61. Judging by the preservation, the specimens seem to have come from the higher parts of the section. Mzinene Formation, upper Lower or lower Middle Cenomanian.

Dimensions

Specimen	MxWb	MxWh	Wb/Wh	MnWb	MnWh	Wb/Wh	D	Ti	Ri
D1002a	5.1	7.2	0.71	5.1	6.0	0.85	30	4.0	—
D1002b	7.1	8.3	0.85	5.7	7.1	0.80	37	3.24	—
H210/34	8.6	12.0	0.72	7.6	10.6	0.72	25	5.6	—
D1004i	9.9	14.8	0.67	9.7	13.5	0.72	34	3.8	5
H210/23	10.6	12.7	0.83	9.5	11.1	0.86	31	5.2	—
D1004d	12.7	16.4	0.77	10.2	14.7	0.69	38	4.5	—
D1004b	13.6	19.5	0.70	13.0	17.7	0.73	59	3.05	3-4
D1003b	13.8	15.0	0.92	12.0	14.3	0.90	72	0.91	4
D1003c	15.7	19.3	0.81	—	—	—	—	—	—
A1063	16.4	17.2	0.95	16.2	16.2	1.0	40	2.5	—
D1004	18.6	22.9	0.81	—	21.2	—	83	2.0	—
H210/31	19.5	22.6	0.86	18.2	23.4	0.77	46	1.7	—
D1003a	23.0	24.7	0.93	18.5	21.4	0.86	110	3.0	6

Fig. 4 (see facing page). *Sciponoceras cucullatum* Collignon, 1964. A-C. NMB D1003a. D. NMB D1003b, both from an imprecisely located horizon on the Skoenberg at locality 61, Zululand, Mzinene Formation, ?Middle Cenomanian. Arrow points to shallow constriction. Both $\times 1$.

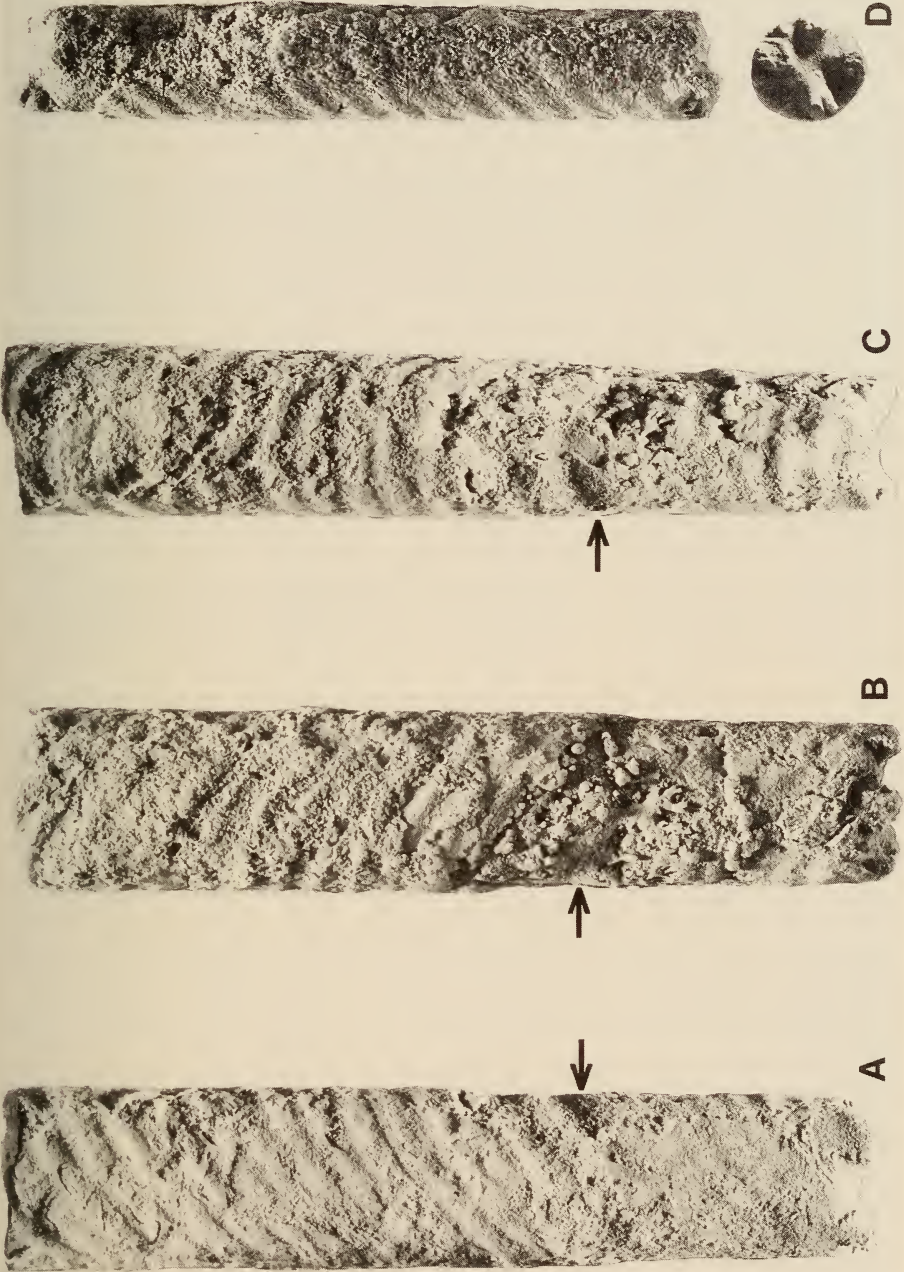


Fig. 4

Description

Preservation of the material from this locality is characteristic: specimens are either preserved as internal moulds in a combination of glauconitic silt and sparry calcite, or with part of the original shell preserved in recrystallized sparry calcite. Unfortunately, recrystallization of the calcite, plus the fact that most specimens were found eroded on the surface, has obliterated most of the surface ornament.

The species reaches large size; the largest Zululand specimen, D1003a (Fig. 4A–C) is still septate at a whorl height of nearly 25 mm. The Madagascan holotype (Fig. 6A–C) is adult with a fully developed, recurved, hooded aperture at $Wb = 20.7$ mm.

There is considerable variation in whorl shape; it varies from circular, to high oval, with $Wb : Wh$ ratio as little as 0.67. This variation is partially due to ontogenetic change: smaller specimens are generally more compressed laterally than large specimens, which tend to be almost circular in cross section.

Where the shell is preserved, ornament is seen to consist of ribbing that is distinctly prorsiradiate on the flanks, transverse or feebly convex on the venter, and also straight and transverse, but weakened on the dorsum. Density of ribbing is approximately 5 per whorl height. On internal moulds the surface is completely smooth. Constrictions are very rare, e.g. D1003a (Fig. 4A–C); these seem to follow the same direction as the ribs and are strongest over the venter. As a result of the preservation, only parts of the suture are visible.

Discussion

We have not yet been able to examine Venzo's (1936) described material, but the figure and the locality data indicate that it is very probable that his *Baculites gaudini* (Venzo 1936: 118 [60], pl. 10 [6] (fig. 3)) belongs to this species, and not to *Lechites gaudini*. Because of the rare and weak development of constrictions it is quite easy to understand Venzo's error in referring this species to *Lechites* rather than to *Sciponoceras*.

In retrospect, we suspect that our earlier reference to *S. roto* from Zululand (Kennedy & Klinger 1975: 277) may, in part, have been based on this species. As is shown below, *S. roto* lacks the distinctive prorsiradiate ribbing of the present material and has regular constrictions, thus easily distinguishing it from *S. cucullatum*.

As far as the large size is concerned, *S. cucullatum* is close to *S. santacrucense* Leanza (1970: 212, pl. 11 (figs 1–7)) (Fig. 6E herein), a rather poorly known species from Santa Cruz Province, Argentina. This species was initially dated as Cenomanian, but this was based on incorrect stratigraphic information. *Sciponoceras santacrucense* occurs below a level with abundant *Placentoceras* at Puesto el Alamo (Riccardi & Aguirre Urreta 1988; personal observation), which would probably date it as late Turonian. *Sciponoceras santacrucense* has distinct, regular, albeit widely spaced constrictions that easily distinguish it from *S. cucullatum*.

Sciponoceras gracile (Shumard, 1860) (see Kennedy 1988: 108, pl. 20 (figs 1–14, 17–20), text-fig. 38 for the most recent review) from the Upper Cenomanian, grows to similar large size, but the ornament consists of fine ribs

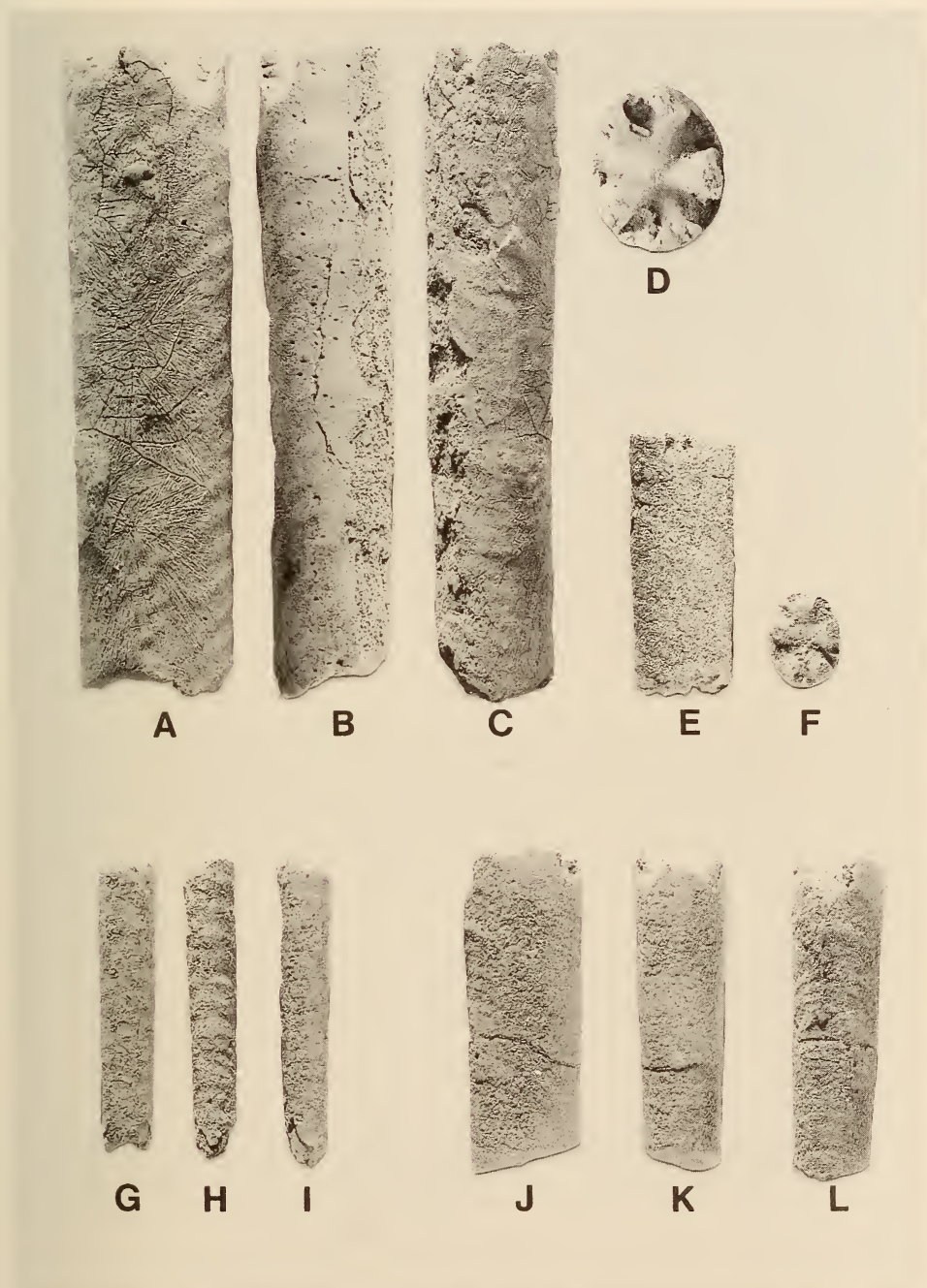


Fig. 5. *Sciponoceras cucullatum* Collignon, 1964. A-D. NMBD1004. E-F. NMBD1004c. G-H. NMBD1002. J-L. NMBD1004d. All from an imprecisely located horizon on the Skoenberg at locality 61, Zululand, Mzinene Formation, ?Middle Cenomanian. All $\times 1$.

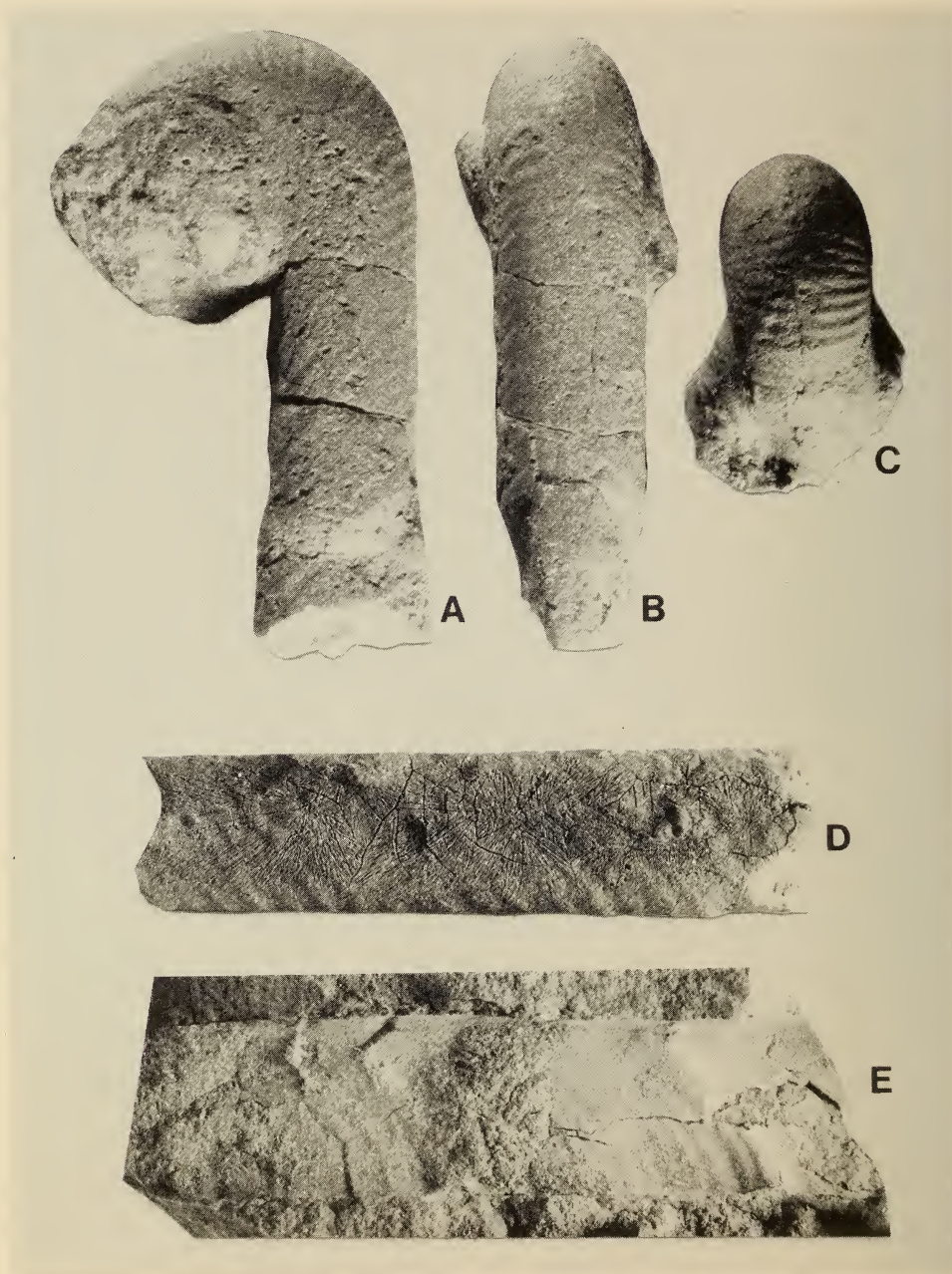


Fig. 6. A-D. *Sciponoceras cucullatum* Collignon, 1964. Plaster cast of the holotype from the Lower Cenomanian zone of *Mantelliceras mantelli* and *Calycceras newboldi* of gisement 505, west of the falls of Mahaboboka (Manera), Madagascar. D. NMBD1004 from an imprecisely located horizon on the Skoenberg at locality 61, Zululand, Mzinene Formation, ?Middle Cenomanian. E. *Sciponoceras santacruzense* Leanza, 1970. Impression of specimen from the Turonian of Puesta el Alamo, Santa Cruz Province, Argentina. All $\times 1$.

that are strongest on the ventral half of the flanks, and constrictions occur fairly regularly at distances ranging from 1 to 1.5 major diameters, according to Wright & Kennedy (1981: 113).

Sciponoceras kossmati (Nowak, 1908) is difficult to interpret (see Wright & Kennedy 1981: 114), but it appears that most of the material from California and Hokkaido, described by Matsumoto (1959: 106, pl. 31 (figs 2a–b, 3), text-figs 4a–b, 5a–b, 6a–b) and Matsumoto & Obata (1963: 13, pl. 3 (fig. 2), pl. 4 (fig. 1), pl. 5 (figs 1–3), pl. 6 (figs 3–5), text-figs 5–25) as *S. kossmati*, is indistinguishable from *S. gracile*.

Sciponoceras orientale Matsumoto & Obata (1963: 18, pl. 3 (fig. 1), pl. 6 (figs 1–2), pl. 7 (figs 1–6), pl. 9 (fig. 6), text-figs 33–49) from the Lower and Middle Turonian of Hokkaido is also quite large, but is distinguished by the frequent constrictions and coarse ribbing.

The recurved aperture of the holotype of *S. cucullatum* is totally unlike any of the known apertures of other *Sciponoceras* species.

Occurrence

'Lower' Cenomanian of Madagascar, Lower and ?Middle Cenomanian, Zululand.

Sciponoceras roto Cieřliński, 1959

Fig. 2P

- 1907 *Baculites baculoides* Mantell; Pervinquière, p. 92 (pars), pl. 4 (fig. 8 only), non pl. 4 (fig. 7), text-fig. 22.
- 1940 *Cyrtochilus pervinquierei* Breistroffer, p. 99 (29). (*nomen nudum*)
- 1959 *Sciponoceras roto* Cieřliński, p. 39, pl. 4 (fig. 10), text-fig. 14 (II).
- 1971 *Sciponoceras roto* Cieřliński; Kennedy, p. 10, pl. 3 (fig. 7).
- 1972 *Sciponoceras roto* Cieřliński; Hancock *et al.* pl. 81 (fig. 8).
- 1975 *Sciponoceras roto* Cieřliński; Kennedy & Klinger, p. 277 (pars).
- 1979 *Sciponoceras* cf. *roto* Cieřliński; Kennedy *et al.* p. 10, pl. 1 (fig. 4).
- 1980 *Sciponoceras roto* Cieřliński; Marcinowski, p. 254, pl. 3 (figs 14–15).
- 1985 *Sciponoceras roto* Cieřliński; Marcinowski & Wałaszczyk, pl. 1 (fig. 9).
- 1991 *Sciponoceras roto* Cieřliński; Delamette & Kennedy, p. 460, figs 17.8–17.13, 17.16–17.23.
- 1995 *Sciponoceras roto* Cieřliński; Wright & Kennedy, p. 315, pl. 94 (figs 13–19), pl. 95 (fig. 4), pl. 98 (fig. 28), text-figs 131J–L, N. (*cum. synonym.*)

Type

Cieřliński based this species on nine syntypes; as yet, no lectotype has been designated.

Material

SASEM191 from an unspecified horizon at locality 181, Zululand, Mzinene Formation, Cenomanian I–II.

Description

The specimen consists of part of the phragmocone and body chamber. The whorl section is circular; Wb : Wh 9.5 : 9.5 (= 1.0) at the greatest diameter.

Apart from two prominent constrictions spaced at about two whorl heights apart, the surface of the internal mould is nearly smooth. Faint ribs occur on the venter.

Discussion

Sciponoceras roto is easily identified by the circular whorl section and lack of ornament between the constrictions. The specimen from Zululand differs from the European material in having the constrictions slightly closer spaced—twice the whorl height compared to three times. We do not know if this feature is significant.

Breistroffer (1940: 99 (29)) erected a new species, *Cyrtochilus pervinquieri*, for one of Pervinquier's specimens of *Baculites baculoides*. As Wright & Kennedy (1995: 315) have noted, this is a *nomen nudum*. In any case, the specimen is close to, if not identical with, *S. roto*.

As discussed above, earlier records of *S. roto* from Zululand (Kennedy & Klinger 1975: 277) are probably partially based on misidentified *S. cucullatum*.

Occurrence

Sciponoceras roto is rare and known from the Lower Cenomanian of Poland, southern England, France, Germany, Mangyschlak, Iran, Tunisia, Madagascar and Zululand.

Genus *Baculites* Lamarck, 1799

(= *Homaloceratites* Hupsch, 1768 (*non binom.*); *Euhomaloceras* Spath, 1926)

Type species. Baculites vertebralis Lamarck, 1799: 80, by subsequent designation of Meek (1876: 80).

Diagnosis

Planispiral ammonitella followed by straight or curved shaft; body chamber may curve in some. Size variable, up to 2 m in length; probably dimorphic. Ornament variable, from nearly smooth with only growth striae around periphery, to crescentic ribs that are strongest on dorsolateral region, but may be circumperipheral, to distinct dorsolateral nodes, which may be round, crescentic or, rarely, longitudinally elongated. In some, the venter may be distinctly corrugated, associated either with or without ventrolateral ribbing. Aperture simple, in line with long axis of shell, short dorsal rostrum, prominent lateral sinus and straight to slightly curved ventral rostrum; may be flared in some species. Suture variable, ranging from simple, subquadrate lobes and saddles with open bases with simple incisions or phylloid folioles, to highly dendritic, with saddles and lobes with slender bases.

Discussion

Of all the heteromorph ammonite genera, the genus *Baculites* probably poses most problems in identification and global stratigraphic correlation. The great number of monotypical and/or endemic *Baculites* species that exist in the

literature, as well as gross misidentifications (e.g. *B. ovatus*, typically from the Upper Campanian of North America, allegedly from the Coniacian of Venezuela (Reyment 1958) or *B. inornatus*, typically Campanian but reportedly from the Lower Coniacian of Venezuela (Renz 1982)), all bear testimony to this problem.

Reasons for the taxonomic difficulties are due to a combination of various factors. These include:

- (1) Extreme degree of intraspecific variation. This is especially obvious in ornate species; these may vary from completely smooth to heavily ribbed or tuberculate (see e.g. *B. anceps* or *B. capensis*).
- (2) Inornate (smooth) species are virtually impossible to identify unless they have a very characteristic whorl section and/or suture line and the stratigraphic position is known.
- (3) Apparent endemism of some *Baculites* species and restriction to distinct bio(?)geographic regions, i.e. U.S. Western Interior, Europe and Indo-Pacific regions, as well as possibly the U.S. Gulf Coast–Atlantic region and North Africa–Middle East regions.

Details of these problems are to be discussed fully in our forthcoming synthesis of the family Baculitidae (Klinger & Kennedy in press).

Fortunately, the descriptions and/or revision of the majority of the baculitid faunas of these major regions are the work of a few persons. Consequently, the taxonomic criteria within a certain geographic region are more or less constant.

The baculitid faunas of the U.S. Western Interior were dealt with primarily by Reeside (1927*a*, 1927*b*) and especially Cobban (1951 onwards), and recently with the assistance of Kennedy. The northern extension of the Western Interior region into West Greenland was covered by Birkelund (1965). In the Indo-Pacific region, the baculitids of California, Hokkaido and Honshu were monographed by Matsumoto (1959), Matsumoto & Obata (1963) and Obata & Matsumoto (1963), respectively; Ward (1978) revised the baculitids of Washington State and British Columbia. Those of Madagascar were described virtually single-handedly by Collignon (1931 to 1971). Major contributions from other parts of the Indo-Pacific region include New Zealand (Marshall 1926; HENDERSON 1970), Antarctica (Olivero 1984, 1992), the Austral Basin of South America (Hünicken 1965; Hünicken *et al.* 1975, 1980) and Argentina (Leanza 1964, 1967).

In contrast, *Baculites* is poorly known in the European and Asian regions. Recent revision of the Upper Cretaceous ammonite faunas of Europe, especially those of France by Kennedy (1984 onwards) and Kennedy & Summesberger (1986, 1987), have clarified the taxonomy of most of the Coniacian, Santonian and Maastrichtian *Baculites* species. The succession and systematics of the majority of *Baculites* species of the Campanian Stage still have to be worked out.

Distribution of *Baculites* on either side of the Atlantic is erratic. The oldest *Baculites* in Angola is an as yet undescribed Late Turonian–Early Coniacian species, which is transitional between *B. yokoyamai* and *B. codyensis* (M. R. Cooper collections, S.A. Museum; herein Fig. 131N–R, 132) or *B. capensis*. Cooper (1988) recorded *B. capensis* from the Lower Campanian. Haughton

(1925, 1926) and Howarth (1965) described *B. subanceps* (Figs 130, 131A-H) from the Upper Campanian or Lower Maastrichtian, and Haas (1943: 13, figs 15-19) described *B. anceps* (herein Fig. 131I-M) from the Lower Maastrichtian. A single baculite species, *B. teichert* is known from the Maastrichtian of Nigeria.

Baculites from the Atlantic seaboard and the Gulf Coast region of the U.S.A. (see e.g. Adkins 1929; Stephenson 1941; Cobban 1974; Cobban & Kennedy 1991a, 1991b, 1992a, 1992b, 1993; Kennedy & Cobban 1993a, 1993b, 1993c, 1993d, 1993e) bear little resemblance to those of Angola or of the Western Interior.

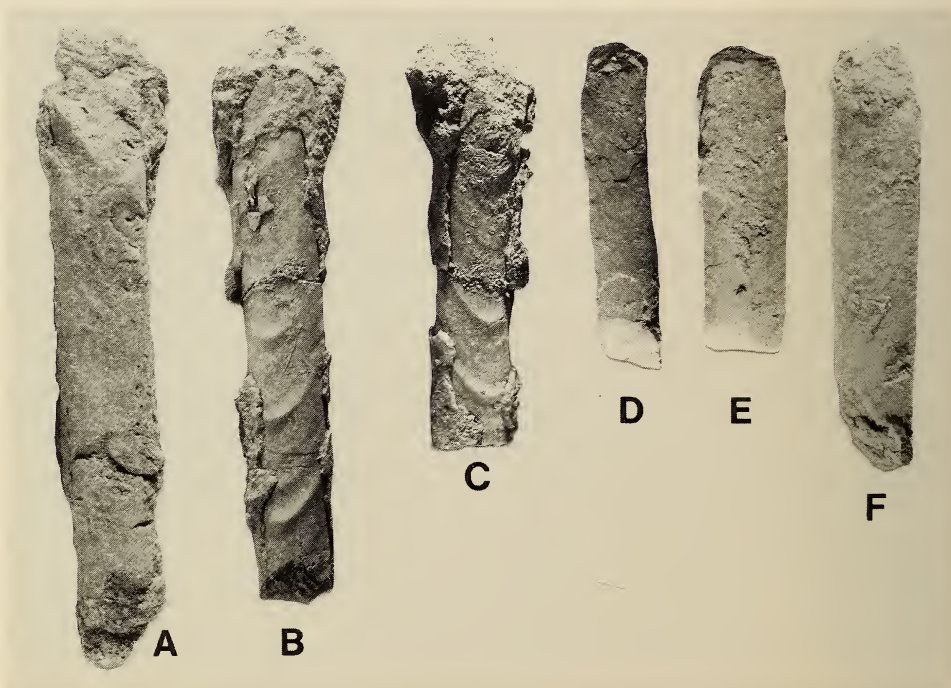


Fig. 7. A-F. *Baculites yokoyamai* Tokunaga & Shimizu, 1926. A. NMBD1158/2. B-C. NMBD1158/3, specimen with distinct ribbing on body chamber. D. NMBD1158/4. E. NMBD1158/1. F. NMBD1158/7. All from a locality on the Msunduzi River, Van Hoepen collection, presumably the equivalent of locality 145 of Kennedy & Klinger (1975: 299), St Lucia Formation, Coniacian II. Scale $\times 1$.

The baculitid records from Central America and Brazil are scant. Only *B. yokoyamai* is known from the Lower Coniacian of Venezuela and *B. kegei* from the Maastrichtian of Brazil.

The North African baculitids were last studied by Pervinquière (1907, 1910) and, from his descriptions, it appears that *Baculites* is rare. Lefeld & Uberta (1992) recently mentioned *Baculites* in association with *Nostoceras* from Libya.

The baculitids of the Middle East, specifically Israel, appear to contain a mixture of European, Indo-Pacific and U.S. Gulf Coast and Atlantic seaboard

elements, as well as some endemics. Dr Z. Lewy (Jerusalem) has shown us an extensive collection of Campanian to Maastrichtian *Baculites*, which he intends to describe. This as yet undescribed collection shows that the older records of Blanckenhorn (1905), Taubenhaus (1920) and Picard (1929) are badly in need of revision. Baculitids from Egypt were recently described by Luger & Gröschke (1989) and Hamama & Kassab (1990). These include *B. subanceps* and *B. ovatus*—Indo-Pacific and Gulf Coast–Atlantic region species. The record of *B. scotti*, a Western Interior species by Hamama & Kassab (1990: 462, pl. 2 (figs 5–9)) is probably incorrect. Alharithi & Ibrahim (1992) also recorded *B. ovatus* from the Maastrichtian of Jordan.

The Upper Coniacian to Lower Maastrichtian *Baculites* fauna of the U.S. Western Interior is mainly endemic (see review by Cobban 1994), but Kennedy (1993) has recently recorded three typical Western Interior species from the Campanian and Maastrichtian of Belgium. Some parallel development of the sutures and ornament occurs in the baculites of the Western Interior and of the Indo-Pacific regions (Klinger & Kennedy in press). Differences between baculites of the European and Indo-Pacific regions appear to be of lesser magnitude, and there seems to have been a much greater amount of faunal interchange between these two regions.

Occurrence

The genus first appears in the Lower Turonian, Zone of *Pseudaspidoceras flexuosum*, of the Western Interior of the U.S.A., as *B. yokoyamai*, and also in the Lower Turonian of Romania as *Baculites* aff. *undulatus* and *Baculites* sp. (Szász 1986); it persists to the end of the Maastrichtian (Birkelund 1979, 1993).

Baculites yokoyamai Tokunaga & Shimizu, 1926

Figs 7–11, 12A–I

- 1926 *Baculites* (*Lechites*) *yokoyamai* Tokunaga & Shimizu, p. 195, pl. 22 (fig. 5a–b), pl. 26 (fig. 11).
- 1931 *Baculites Besairiei* Collignon, p. 37, pl. 5 (figs 6, 6a, 7, 7a, 8, 8a, 9), pl. 9 (fig. 16).
- 1931 *Baculites sulcatus* Collignon, non Baily, p. 36, pl. 5 (figs 3, 3a, 4, 4a, 5, 5a, 13, 13a), pl. 9 (fig. 15).
- 1931 *Baculites Roedereri* Collignon, p. 38, pl. 5 (figs 10, 10a), pl. 9 (fig. 17).
- 1931 *Baculites latelobatus* Collignon, p. 38, pl. 5 (figs 11, 11a, 12, 12a), pl. 9 (fig. 18).
- ? 1958 *Baculites ovatus* Say?; Reyment, p. 7, pl. 1 (figs 1–2), text-figs 1–2.
- 1959 *Baculites* aff. *B. yokoyamai* Tokunaga & Shimizu; Matsumoto, p. 118, text-fig. 26.
- 1963 *Baculites yokoyamai* Tokunaga & Shimizu; Matsumoto & Obata, p. 30, pl. 8 (fig. 5), pl. 10 (figs 1–6), pl. 11 (figs 1, 4, 5), pl. 12 (fig. 3), pl. 14 (fig. 4), text-figs 72–87.
- 1965 *Baculites besairiei* Coll.; Collignon, p. 18, pl. 420 (figs 1745–1746).
- 1972 *Baculites* cf. *B. yokoyamai* Tokunaga & Shimizu; Cobban & Scott, p. 48, pl. 20 (figs 15–21).
- 1975 *Baculites* cf. *B. yokoyamai* Tokunaga & Shimizu; Hattin pl. 8 (figs F, H).
- 1977 *Baculites* cf. *B. yokoyamai* Tokunaga & Shimizu; Kennedy, p. 271, fig. 17 (1, 2).
- 1978 *Baculites* cf. *B. yokoyamai* Tokunaga & Shimizu; Hattin & Siemers, text-fig. 7.2.

- 1980 *Baculites yokoyamai* Tokunaga & Shimizu; Cobban & Hook, p. 13, pl. 4 (figs 9–10).
 1982 *Baculites inornatus* non Meek; Renz, p. 105, pl. 34 (figs 3–4, 5a–b, 6), text-fig. 80.
 1983 *Baculites yokoyamai* Tokunaga & Shimizu; Cobban & Hook, p. 7, pl. 1 (figs 1–7).
 1983 *Baculites yokoyamai* Tokunaga & Shimizu; Cobban, p. 16, pl. 14 (figs 6–8).
 1984 *Baculites yokoyamai* Tokunaga & Shimizu; Cobban, p. 14, pl. 1 (figs 5–6).
 1986 *Baculites yokoyamai* Tokunaga & Shimizu; Cobban, fig. 3H–I.
 1988 *Baculites yokoyamai* Tokunaga & Shimizu; Kennedy, p. 110, pl. 23 (figs 8–10), text-fig. 29c.
 1988 *Baculites yokoyamai* Tokunaga & Shimizu; Kennedy & Cobban, p. 608, fig. 3 (1, 2, 7, 13, 14, 18, 19).
 1989 *B. yokoyamai* Tokunaga & Shimizu; Kennedy *et al.* p. 101, fig. 31e–h.
 1990 *Baculites yokoyamai* Tokunaga & Shimizu; Cobban, p. B11, pl. 9 (figs 16–22).
 1991a *Baculites yokoyamai* Tokunaga & Shimizu; Kennedy & Cobban, p. 69, pl. 13 (figs 4–10, 17–21, 24–28, 34–37, 41–42), text-fig. 22A.
 1992 *Baculites yokoyamai* Tokunaga & Shimizu; Summesberger, p. 124, pl. 8 (figs 10–11).

Type

Holotype, by monotypy, is the specimen figured by Tokunaga & Shimizu (1926, pl. 22 (fig. 5a–b), pl. 26 (fig. 11)) from the lower Futaba Beds in the upper reaches of the Sakurazawa in Oriki, Hirono-mura, Fukushima prefecture, north-east Honshu. The type was destroyed by fire during World War II. A specimen from the collections of the Kyushu University, GK 4580 from the Bannosawa in Hokkaido, of Coniacian age, zone of *Inoceramus uwajimensis*, was to be designated neotype by Matsumoto & Obata (see Matsumoto & Obata 1963: 30–31).

Material

NMB D1158/1–2, ?3, 4–8, all from a locality on the Msundusi River, collected by E. C. N. van Hoepen in 1923, presumably equivalent to Kennedy & Klinger's (1975: 299) locality 145, St Lucia Formation, Coniacian II (associated with *Forresteria (F.) madagascariensis* Collignon, 1965).

Dimensions

Specimen	MxWb	MxWh	Wb/Wh	MnWb	MnWh	Wb/Wh	D	Ti
D1158/4	6.4	8.6	0.74	5.7	8.1	0.70	20	2.5
D1158/7	8.4	11.6	0.72	7.9	9.9	0.80	28	6.1
D1158/1	9.3	12.0	0.77	7.9	10.3	0.77	26	6.5
D1158/5	9.3	12.1	0.77	—	—	—	—	—
D1158/2	—	13.0	—	—	—	—	—	—
D1158/3	8.0	11.7	0.68	7.0	9.9	0.70	50	3.6

Description

This species is rare in Zululand, and known from one locality only. It is easily identified by the elliptical whorl section and the very slow rate of taper in adult specimens. Also, the maximum adult size is small compared to later species of *Baculites* in Zululand.

Only one specimen, D1158/1 (Fig. 7E) has faint traces of ribbing over the venter; all the other specimens are perfectly smooth, both on the shell surface and on internal moulds.

One specimen, D1158/3 (Fig. 7B-C)—a body chamber with part of the last two septa preserved, is identical to the above specimens except that it has distinct, crescentic lateral ribs, which appear to originate in a curved, dorso-lateral tubercle. Unfortunately we cannot determine on the basis of this specimen whether this ribbing is restricted to the body chamber, or is also present on the phragmocone.

The suture is partially exposed in D1158/4 (Fig. 8A) and D1158/3 (Fig. 8B), showing very simple, open subquadrate saddles and lobes.

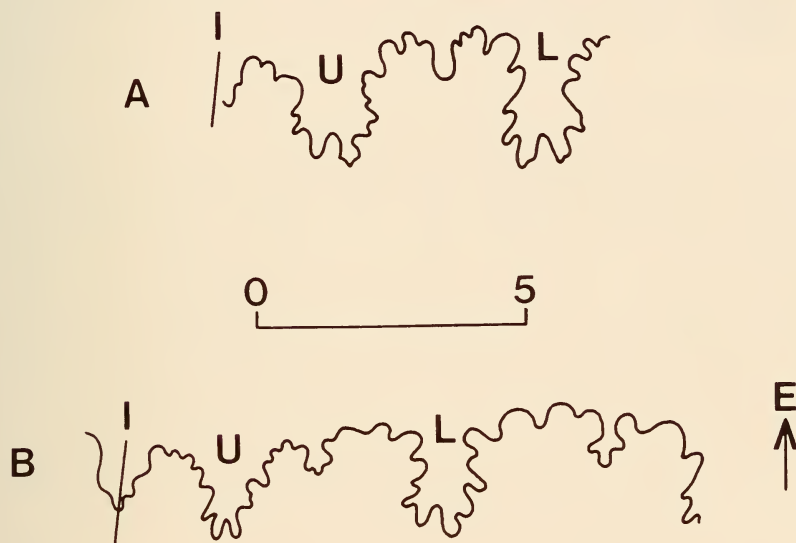


Fig. 8. *Baculites yokoyamai* Tokunaga & Shimizu, 1926. Suture lines.
A. NMBD1158/4. B. NMBD1158/3. Scale bar in mm.

Discussion

Baculites yokoyamai is the best documented species in the early history of the genus *Baculites* and appears to have both a wide geographic distribution and long stratigraphic range. It appears to be the root stock from which the majority of later *Baculites* species has evolved.

The name *B. yokoyamai* has been applied to non-tuberculate baculitids with elliptical whorl section, primitive suture and of Turonian to Coniacian age. The Turonian occurrences are best documented in the U.S. Western Interior, where the species ranges throughout the stage, first appearing in the Lower Turonian Zone of *Pseudaspidoceras flexuosum*. It persists into the Lower Coniacian, Zone of *Inoceramus erectus* of the Western Interior, from where it has recently been fully illustrated by Kennedy & Cobban (1991a). In Hokkaido it persists through the greater part of the Coniacian, although possibly not into the uppermost part, in the Zone of *Inoceramus uwajimensis*.

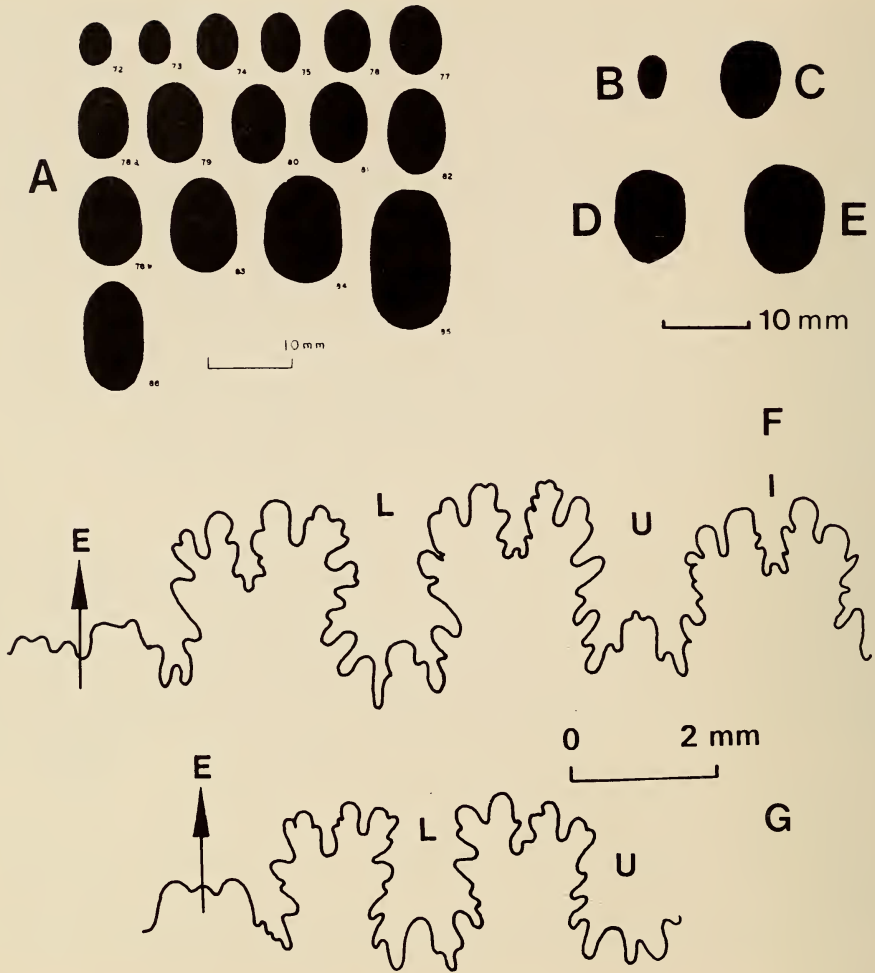


Fig. 9. *Baculites yokoyamai* Tokunaga & Shimizu, 1926. A-E. Whorl sections. A. Japanese specimens (copy of Matsumoto & Obata 1963, text-figs 72-86). B. NMBD1158/8. C. NMBD1158/6. D. NMBD1158/1. E. NMBD1158/5. All $\times 1$. F-G. *Baculites bailyi* Woods, 1906. Suture lines. F. SAM-PCZ8355. G. SAM-PCZ8344.

Our smooth specimens are identical to material described from the U.S. Western Interior and Hokkaido. Kennedy & Cobban (1991a) have recently shown that, even though the majority of *B. yokoyamai* in the lower Coniacian of the Western Interior are smooth, some forms occur with fold-like ribs on the upper part of the flanks (e.g. Kennedy & Cobban 1991a, pl. 13 (figs 20, 24). D1158/3 (Fig. 7B-C) could possibly be interpreted as a more strongly sculptured variant of *B. yokoyamai*, and we see no need for separating it from the latter at present. Nevertheless, the similarity in ornament between D1158/3 and *B. sweetgrassensis* Cobban (1951: 820, pl. 118 (figs 6-9), text-figs 1-3) (see also Kennedy & Cobban 1991a: 70, pl. 14 (figs 24-25, 29-34, 38-42)) is

striking. This latter species, however, has a distinctive ovoid whorl section with a narrow venter.

The relationship between ribbed D1158/3 and smooth forms of *B. yokoyamai* is very similar to that of *B. sweetgrassensis* (ribbed) and *B. mariasensis* (smooth) (Cobban 1951: 818, pl. 118 (figs 10–12), text-figs 4–7)—see also Kennedy & Cobban 1991a: 69, pl. 13 (figs 11–16, 22–23, 29–33, 38–40), pl. 14 (figs 1–23, 26–28, 43–48), text-fig. 25E). The latter species both occur in the Lower Coniacian Zone of *Inoceramus erectus*, and, according to the original description of Cobban (1951: 820), '*B. sweetgrassensis* is an uncommon species The types were collected with *B. mariasensis* in the Colorado shale'. Their co-occurrence, as well as the ratio of smooth to ribbed forms suggests that *B. sweetgrassensis* may be no more than a ribbed form of *B. mariasensis*, in the same relation as the ribbed Zululand specimen of *B. yokoyamai* to the majority of smooth specimens.

Cobban (1951: 817) and Cobban & Reeside (1952) initially identified what is now known as *B. yokoyamai* in North America, as *Baculites* cf. *B. besairiei*. Matsumoto (1959: 117) subsequently suggested that *B. besairiei* Collignon (1931: 37, pl. 5 (figs 6–9), pl. 9 (fig. 16)) might be a synonym of *B. yokoyamai*. Later, Matsumoto & Obata (1963: 34) concluded confidently that 'all the described characters of *Baculites besairiei* Collignon are the same as those of *B. yokoyamai*'.

Collignon had 721 baculitid specimens from the apparently condensed or secondarily concentrated ferruginous conglomerate of Mahagaga, initially dated as Santonian (Collignon 1931), but later as Late Coniacian (Besairie & Collignon 1959). Of these, 531 specimens were discarded as being too fragmentary, leaving 190 specimens to be studied. The majority, 150 specimens, were referred to *B. besairiei* Collignon (1931: 37, pl. 5 (figs 6, 6a, 7, 7a, 8, 8a, 9), pl. 9 (fig. 16)); lectotype herein designated, is the largest figured specimen pl. 5 (fig. 6)) (herein Fig. 10A–C). Collignon (1931: 37) described the variation in strength of ribbing over the venter in *B. besairiei* in detail. In typical forms, the ribs are oblique over the flanks and cross the venter in a sharp chevron. In some, ribbing is thin, in others thick, and in some alternating thick and thin.

In addition to *B. besairiei*, Collignon described three other non-tuberculate baculitids from this assemblage. These include *B. sulcatus* Collignon, *non* Baily (Collignon 1931: 36, pl. 5 (figs 3–5, 13), pl. 9 (fig. 15)) (24 specimens) (herein Fig. 11D–L); *B. roedereri* (Collignon 1931: 38, pl. 5 (fig. 10), pl. 9 (fig. 17)) (herein Fig. 12G–I); holotype by monotypy is the figured specimen; *B. late-lobatus* (Collignon 1931: 38, pl. 5 (figs 11–12), pl. 9 (fig. 18)) (3 specimens) (herein Fig. 12A–F); lectotype, herein designated, is the largest of the two figured specimens (Collignon 1931, pl. 5 (fig. 11)) (herein Fig. 12A–C).

We have been able to examine the figured and some of the unfigured material and agree with Matsumoto & Obata that *B. besairiei* is probably a synonym of *B. yokoyamai*. Certainly as far as the elliptical whorl section and variation in ornament are concerned, there is no valid reason for maintaining them as separate species.

Furthermore, Collignon's *B. sulcatus* definitely does not belong to this Campanian Pondoland species; it lacks the typical strong lateral ornament. Instead, we regard the 24 specimens described by Collignon under that name as slightly

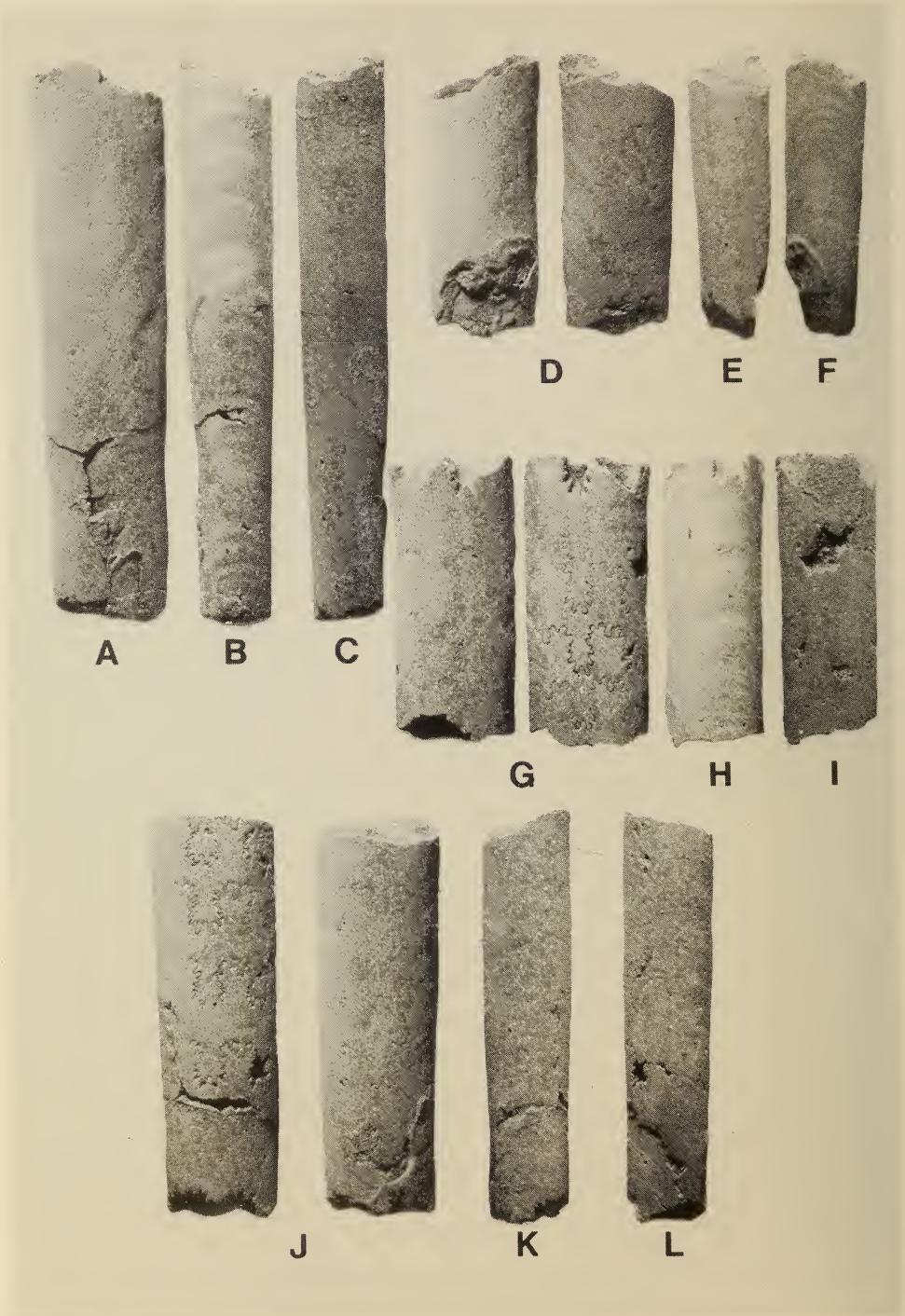


Fig. 10

more strongly ribbed variants of *B. yokoyamai*. Externally, *B. roedereri* is indistinguishable from *B. besairiei*, i.e. *B. yokoyamai*. According to Collignon (1931: 38) it differs in the suture line: the terminations of the lobes are rounded; the first (E/L) saddle is very large and divided by a prominent lobule; the second lateral saddle (L/U) is narrow and much higher than the first; and the antisiphonal saddle (I/U) is very large and very low, divided by a large, pointed lobule. The first lateral lobe (L) is narrow and prominent, the second lateral lobe (U) is smaller than the first and asymmetrical. These differences are trivial and well within the range of variation of *B. yokoyamai* (= *B. besairiei*).

Similarly, *B. latelobatus* was alleged to differ on sutural details. The anti-siphonal saddle (U/I) is elongated above the first lateral saddle (E/L), the first lateral lobe (L) is wide, whereas the second lateral lobe (U) is nearly rudimentary. Again, these differences are well within the limits of variation of *B. yokoyamai* (= *B. besairiei*).

The Mahagaga baculitid assemblage is of extreme interest in that it contains the earliest representatives of tuberculate *Baculites* in Madagascar, i.e. *B. boulei* Collignon (1931: 35, pl. 5 (fig. 2, 2a), pl. 9 (fig. 14)) (herein Fig. 12J-L) and *Baculites* cf. *B. brevicosta* Collignon *non* Schlüter (Collignon 1931: 34, pl. 5 (fig. 1, 1a), pl. 9 (fig. 13)), but these are numerically insignificant compared to unornamented *B. yokoyamai*.

It is difficult to separate *B. yokoyamai* from other contemporary Turonian *Baculites* species. In the Western Interior, the name *B. calamus* Morrow, 1935 (p. 473, pl. 49 (fig. 8a-b)) is used for Turonian *Baculites* with weak lateral ribs (*vide* Cobban & Scott 1972: 49). However, as shown by e.g. Cobban & Hook (1983, pl. 1 (figs 3-6)) and recently Kennedy & Cobban (1991a), some specimens of *B. yokoyamai* also have weak to prominent lateral ornament, and it is difficult to maintain them as separate species. Compared to *B. yokoyamai*, *B. calamus* is extremely rare. We are not quite sure on how many specimens Morrow based his species; he only mentioned the holotype but, according to Cobban & Scott (1972: 49), 'The species is uncommon; we found it in only one bed at one locality' (in Colorado). According to Cobban & Scott (1972: 32, table 3), *B. yokoyamai* occurs throughout virtually the whole of the Turonian, whereas *B. calamus* occurs only in the Middle Turonian *Collignoniceras woollgari* Zone. Rarity alone can not be a criterion for invalidating the species but, combined with the overlapping morphologies, we doubt that *B. calamus* can be separated satisfactorily from *B. yokoyamai*.

The only other Turonian *Baculites* species is *B. undulatus* d'Orbigny, 1850. Matsumoto & Obata (1963: 28) ascribed authorship of this species to Roman & Mazeran, who indeed first provided a description of this species and designated the lectotype (Roman & Mazeran 1913: 11, pl. 4 (figs 6-8)). Although poorly defined, d'Orbigny's Prodrôme species are valid, and authorship of

Fig. 10 (*see facing page*). *Baculites yokoyamai* Tokunaga & Shimizu, 1926. The figured specimens of *B. besairiei* Collignon, 1931. A-C. Lectotype, the original of Collignon, pl. 5 (fig. 6). D-F. The original of Collignon, pl. 5 (fig. 9). G-I. The original of Collignon, pl. 5 (fig. 8). J-L. The original of Collignon, pl. 5 (fig. 7). All from the ferruginous conglomerate at Mahagaga, Madagascar. All unregistered and housed in the collections in Dijon. All $\times 2$.

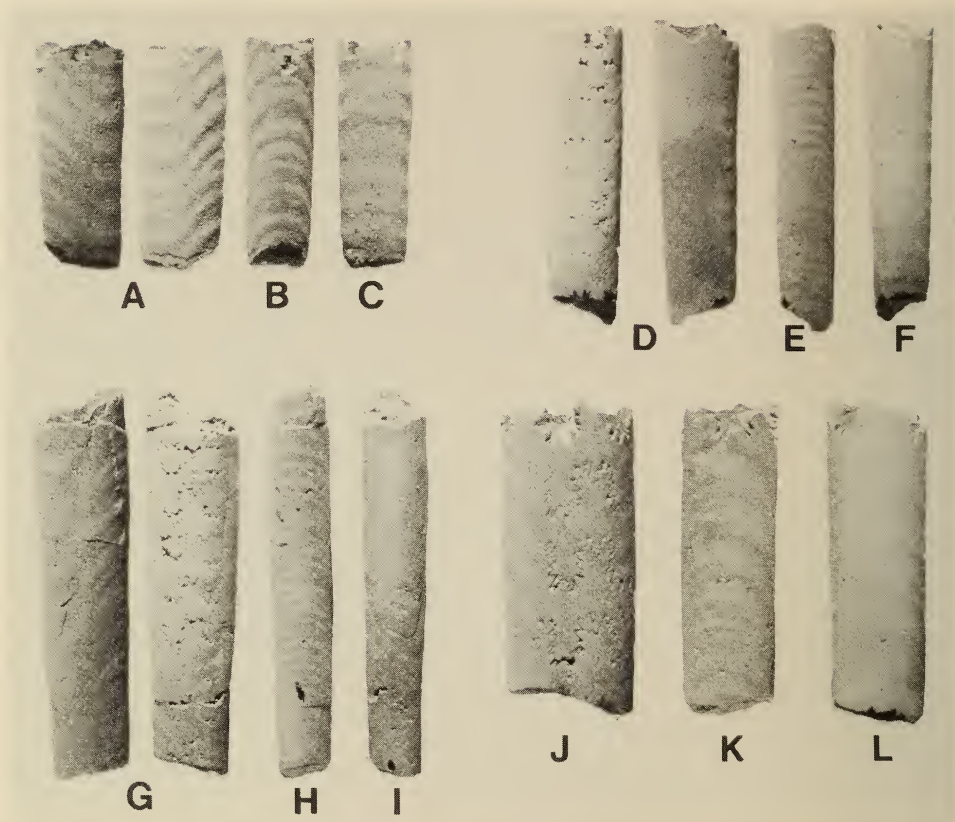


Fig. 11. *Baculites yokoyamai* Tokunaga & Shimizu, 1926. A-C. The original of Collignon (1931, pl. 5 (fig. 13)) *Baculites* aff. *sulcatus*. D-F. The original of Collignon (1931, pl. 5 (fig. 4)). G-I. The original of Collignon (1931, pl. 5 (fig. 3)). J-L. The original of Collignon (1931, pl. 5 (fig. 5)), all originally referred to *Baculites sulcatus*. All from the ferruginous conglomerate at Mahagaga, Madagascar. All unregistered and housed in the collections in Dijon. All $\times 2$.

B. undulatus rests with d'Orbigny. The lectotype was refigured and described by Sornay (1955) and Breton & Bavent (1985: 101-102, figs 1-3).

The name *B. undulatus* has generally been applied to Upper Turonian *Baculites* in Western Europe, especially France (d'Orbigny 1850: 19, 21, no. 21; Roman & Mazeran (1913: 11, pl. 4 (figs 6-8)), and the Chalk Rock of England

Fig. 12 (see facing page). A-I. *Baculites yokoyamai* Tokunaga & Shimizu, 1926. A-C. The lectotype of *B. latelobatus*, the original of Collignon (1931, pl. 5 (fig. 11)). D-F. A paralectotype of *B. latelobatus*, the original of Collignon (1931, pl. 5 (fig. 12)). G-I. The holotype of *B. roedereri*, the original of Collignon (1931, pl. 5 (fig. 10)). J-O. *Baculites capensis* Woods, 1906. J-L. The lectotype of *Baculites boulei* Collignon, the original of Collignon (1931, pl. 5 (fig. 2)). M-O. The original of *Baculites* cf. *B. asperanceps* of Collignon (1931, pl. 3 (fig. 7)). A-L from the ferruginous conglomerate at Mahagaga; M-O from Mokotibe-Tsianaloky. All unregistered and housed in the collections in Dijon. A-L $\times 2$; M-O $\times 1$.

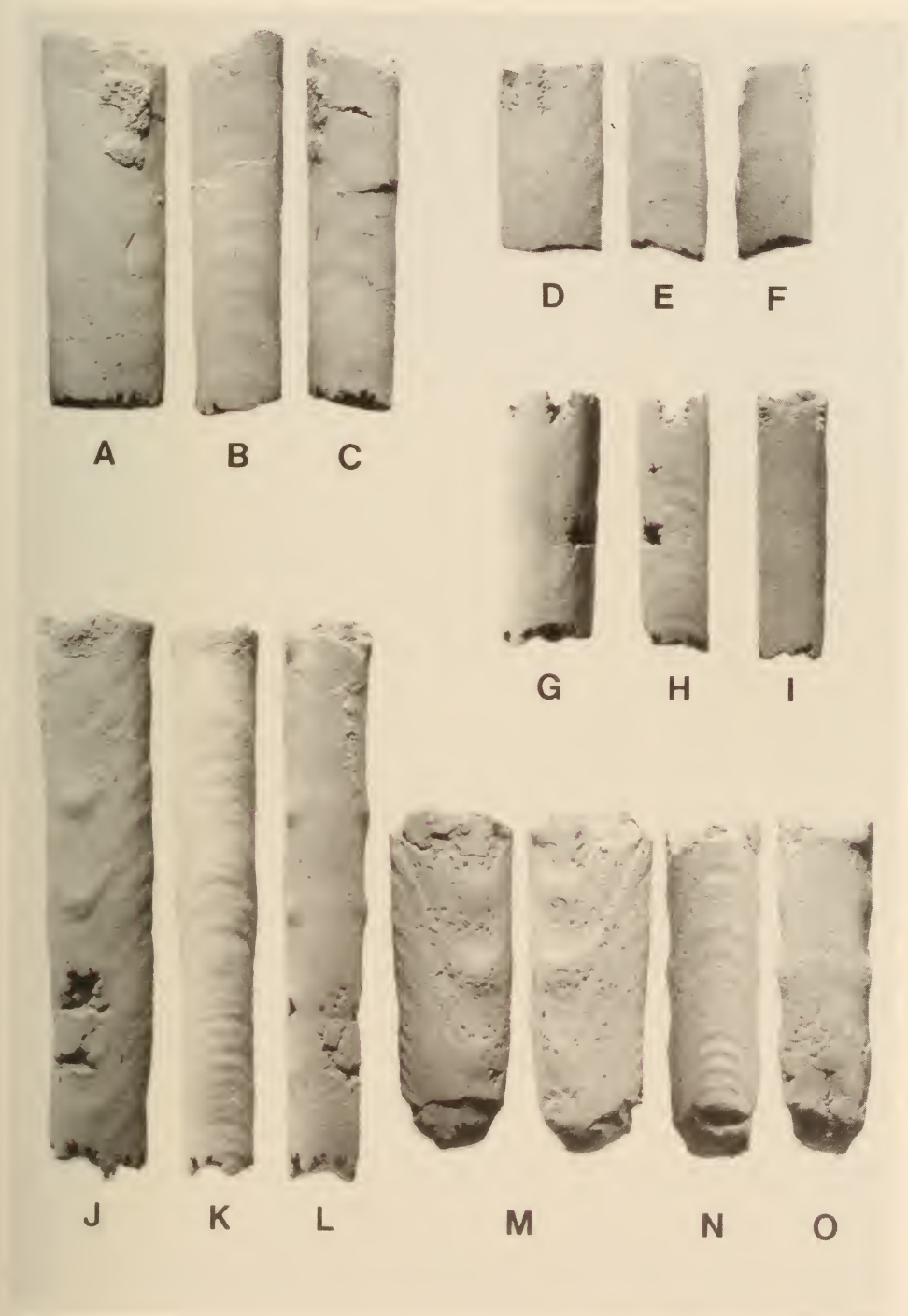


Fig. 12

(Wright 1979: 287, pl. 1 (figs 6–8), pl. 7 (fig. 11)), where it is only known from a few localities; Fritsch & Schloenbach (1872: 49) recorded numerous baculitids from several localities in Bohemia that they considered to probably belong to *B. undulatus*. Unfortunately, the specimens were nearly all secondarily compressed, and none were figured; this makes it difficult to confirm their Bohemian records. That of Jahn (1895: 136, pl. 8 (fig. 8a–c)), as *Baculites* n. sp., however, confirms the occurrence of *B. undulatus* in Bohemia. Matsumoto & Obata (1963: 28, pl. 8 (fig. 4), pl. 9 (figs 1–5), pl. 11 (figs 2–3), text-figs 62–71) recorded *B. undulatus* from the Upper Turonian of Hokkaido.

Kennedy *et al.* (1989: 101, fig. 31i) recently recorded *B. undulatus* from the Upper Turonian *Prionocyclus macombi* and *P. wyomingensis* zones of Trans-Pecos Texas and New Mexico. This figured specimen is very similar to the Middle Turonian *B. calamus*, and we suspect that they may be allied, possibly as a local subspecies or variant of *B. undulatus*.

Szász (1986: 120, pl. 1 (figs 1–2)) recorded *Baculites* aff. *B. undulatus* from the Lower Turonian of Romania, accompanied by a questionable baculitid with ornament very similar to that of *B. calamus*. If the Romanian material is correctly identified as *B. undulatus*, this suggests that *B. yokoyamai* and *B. undulatus* appeared more or less at the same time in Europe and in North America.

Baculites undulatus differs from *B. yokoyamai* mainly in having coarser, less oblique ribbing. Dorsolateral bullae develop in some adult specimens of both *B. undulatus* (see e.g. Wright 1979, pl. 7 (fig. 11)) and *B. yokoyamai* (see above and NMB D1158/3—Fig. 7B–C), and seem to be of little systematic value.

It thus appears that differences between *B. yokoyamai* and *B. undulatus* are found mainly in the ribbing—that of the former being more delicate than that of the latter. In addition, *B. undulatus* has a narrower stratigraphic distribution, being restricted mainly to the Upper Turonian, although it might already occur in the Lower Turonian, whereas *B. yokoyamai* occurs throughout the Turonian, all of the Lower Coniacian and probably persists into the Upper Coniacian.

Differences between *B. yokoyamai* and *B. bailyi* are discussed below.

Feebly ornamented baculitids recorded from the Coniacian of Venezuela, and misidentified as *B. inornatus* Meek (a Campanian species) by Renz (1982: 105, pl. 34 (figs 3–6), text-fig. 80) and as *B. ovatus* Say? (of Late Campanian age) by Reymont (1958: 7, pl. 1 (figs 1–2), text-figs 1–2), are good examples of *B. yokoyamai*, thus extending the geographic range of the species to South America.

Occurrence

Baculites yokoyamai is known from the Turonian and Lower Coniacian of the U.S. Western Interior, Lower Coniacian of Venezuela, and Coniacian of Hokkaido (though apparently not extending to the uppermost part of the stage), Middle Coniacian of Zululand, and Upper Coniacian of Madagascar. Dubious specimens have recently been recorded from the Middle Turonian of Austria (Summesberger 1992: 124).

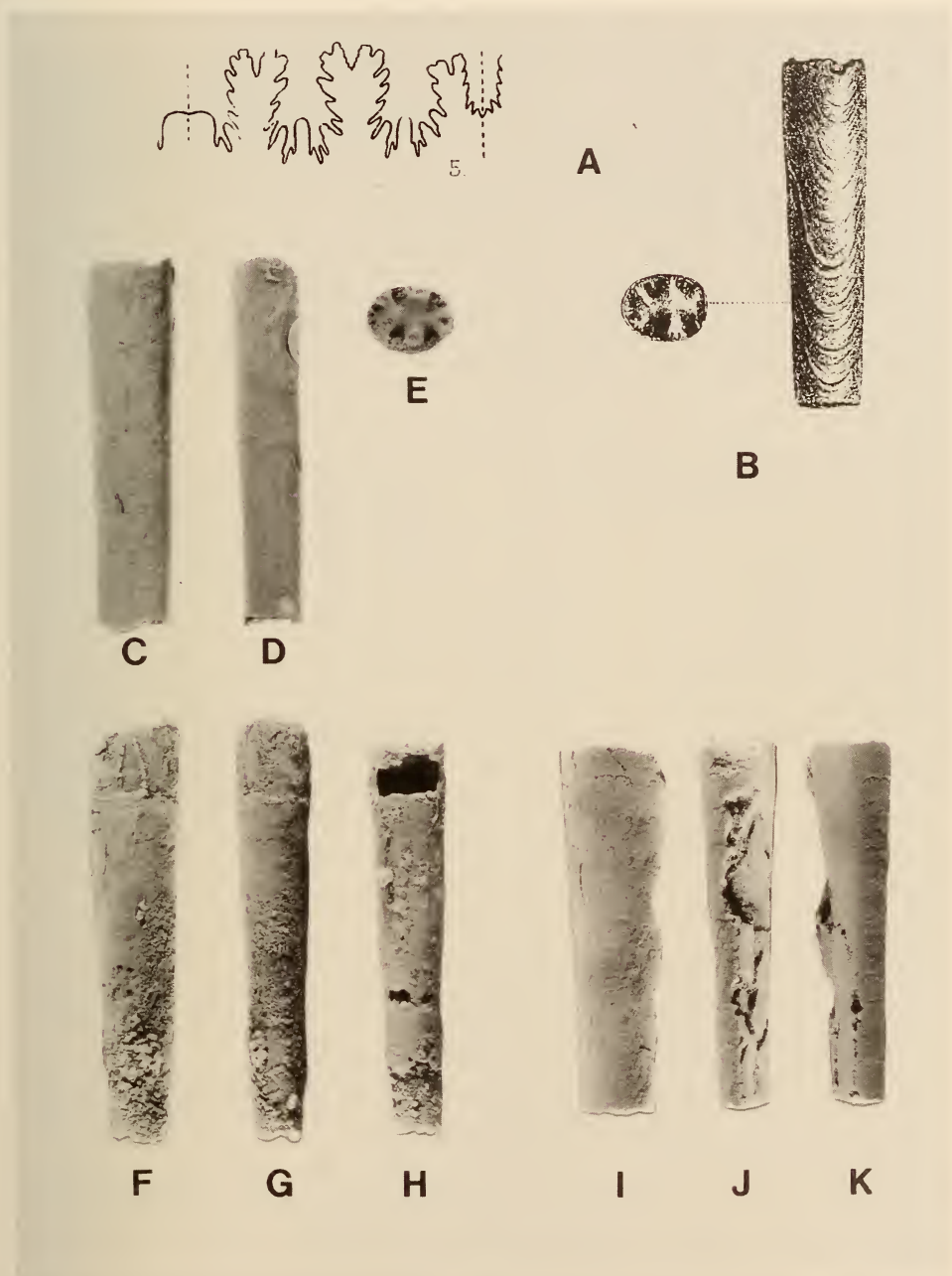


Fig. 13. *Baculites bailyi* Woods, 1906. A. Copy of the suture line figured by Woods (1906, pl. 44 (fig. 5)) based on a paratype in the now missing Griesbach collection. B. Copy of Baily (1855, pl. 11 (fig. 5a-b)) of the holotype of *B. bailyi* (as *B. sulcatus*). C-E. The holotype, BMNH C11372. F-H. SAM-PCO5994a. I-K. SAM-PCO5994b. Both from dredge samples off the Natal South Coast. All except A $\times 1$. Photographs in C-E by courtesy of Natural History Museum, London.

Baculites bailyi Woods, 1906

Figs 13-23, ?34M-R, 67K-Q, 78A-B

- 1855 *Baculites sulcatus* Baily, p. 457 (pars), pl. 11 (fig. 5a-b only, *non* 5c).
 ? 1904 *Baculites* sp. Etheridge, p. 90, pl. 3 (fig. 24).
 1906 *Baculites Bailyi* Woods, p. 341, pl. 44 (fig. 5).
 ? 1921 *Baculites Bailyi* Woods; van Hoepen, p. 18, pl. 3 (figs 9-10).
 1921 *Baculites bailyi* H. Woods; Spath, p. 261.
 1922 *Baculites bailyi* Woods; Spath, p. 146.
 ? 1930 *Baculites Bailyi* Woods; Besairie, p. 223, pl. 21 (fig. 7 only, *non* 6).
 1963 *Baculites bailyi* Woods; Matsumoto & Obata, p. 35, pl. 20 (figs 1-2), pl. 21 (fig. 5), text-figs 88-89, 116-120, 140-142.
 1969 *Baculites bailyi* Woods; Collignon, p. 21, pl. 520 (fig. 2051).
 1977 *Baculites bailyi* Woods; Klinger & Kennedy, p. 75, fig. 5D.
 1978 *Baculites bailyi* Woods; Ward, p. 1148, pl. 1 (figs 5-7), text-fig. 5A-D.
 1984 *Baculites bailyi* Woods; Olivero, p. 57, pl. 1 (figs 1-5), text-fig. 1a-b.
 1985 *Baculites bailyi* Woods; Klinger, p. 5, fig. 4E-H.
 ? 1988 *Baculites* cf. *kirki* Matsumoto; Riccardi & Aguirre-Urreta, p. C389, pl. 3 (figs 4-8).

Types

Holotype, by original designation of Woods (1906: 342) is the specimen figured by Baily (1855, pl. 11 (fig. 5a-b)), BMNH C11372 (herein refigured as Fig. 13C-E), from an unspecified horizon at the type section of the Mzamba Formation, Mzamba Estuary, Pondoland, Transkei. Probable paratypes are SAM-4822 and SAM-13103 (Fig. 67M), both also from an unspecified horizon at the Mzamba Estuary.

Material

We have more than one hundred specimens from the following localities:

- (1) Locality 1, Mzamba Formation, Pondoland, Transkei, Santonian II.
- (2) Locality 10, Zululand (locality d of Spath 1921: 221-222), St Lucia Formation; the locality extends from Coniacian II at the base to probably as high as Campanian.
- (3) Locality 13, Zululand, St Lucia Formation, Coniacian II or III.
- (4) Locality 72, Zululand, St Lucia Formation, Coniacian III.
- (5) Locality 73, Zululand, St Lucia Formation, Coniacian IV (associated with *Peroniceras (Zuluiceras) modestum*).
- (6) Locality 74, Zululand, St Lucia Formation, the section extends from Santonian I to Campanian I.
- (7) Locality 77, Zululand, St Lucia Formation, Coniacian V.
- (8) Locality 78, Zululand, St Lucia Formation, Santonian I-II.
- (9) Locality 80, Zululand, St Lucia Formation, Coniacian V.
- (10) The top of the section at locality 92, Zululand, St Lucia Formation, Coniacian III.

Fig. 14 (*see facing page*). *Baculites bailyi* Woods, 1906. A-I. SAM-PCZ8391. J-Q. SAM-PCZ8357. Both from locality 99, Zululand, St Lucia Formation, Santonian I or II. A-D, J-M $\times 1$, E-H, N-Q $\times 2$, I $\times 4$.

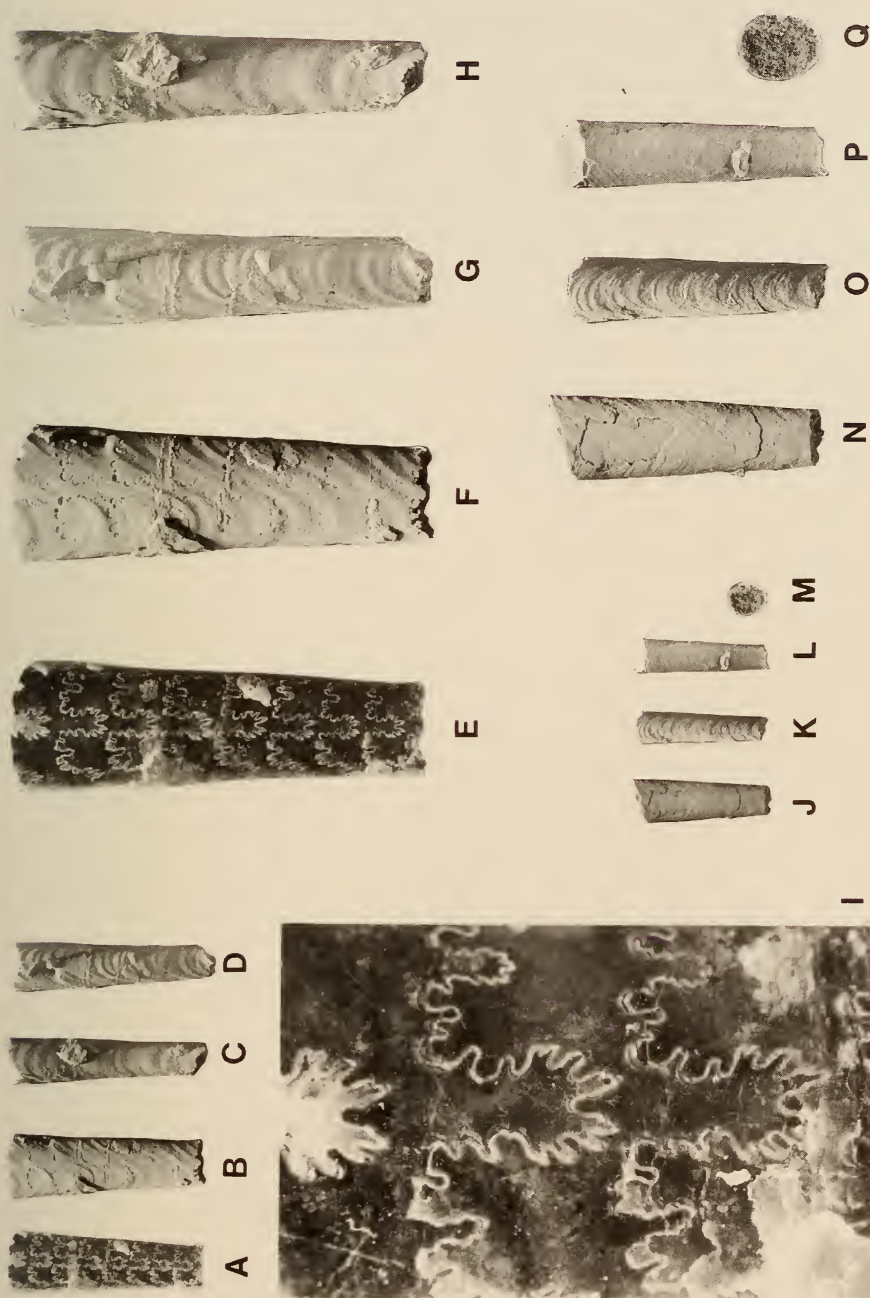


Fig. 14

- (11) Locality 96, Zululand, St Lucia Formation, Coniacian V or Santonian I.
- (12) Locality 98, Zululand, St Lucia Formation, Santonian ?II.
- (13) Locality 99, Zululand, St Lucia Formation, Santonian I or II.
- (14) Locality 100, Zululand, St Lucia Formation, Santonian I.
- (15) Locality 101, Zululand, St Lucia Formation, Santonian II or III.
- (16) Field locality H40, small exposure at pump house on the banks of the Nyalazi River, on Nyalazi Sugar Estate, 2 km east of Nyalazi River Settlement, Zululand, St Lucia Formation, Campanian ?I.
- (17) Field locality H135, loose concretions next to railway line, near Lake View siding, Zululand, St Lucia Formation, Coniacian ?V.
- (18) Dredge samples off the Natal South Coast.

Dimensions

A list of dimensions is given in the appendix.

Max. Wb. (mm)	MxWb/MxWh	MnWb/MnWh	Ti
0-4.9	0.75	0.71	5.3
5.0-9.9	0.75	0.76	5.4
10.0-14.9	0.76	0.75	4.15
15.0-19.9	0.77	0.76	2.97

Description

Woods's (1906: 341) original description is as follows: 'Shell increasing in diameter very slowly. Section oval, compressed, rather narrower on the siphonal than on the antisiphonal side. A small carina is seen in specimens which have the shell well-preserved. Lobes and saddles narrow and rather deep Ornamentation consists of small, inconspicuous ribs, which bend rapidly backwards from the siphonal margin; below the middle of the shell they curve round and pass forward over the anti-siphonal margin.'

Our material shows that this is essentially an inornate species with ovoid whorl section, which, in typical specimens, has a venter that is narrower than the dorsum and may even be acute; but in some, the whorl section may be near-circular. Lateral ornament consists of fine striae only, which may strengthen on the ventral half of the flanks and cross the venter with a distinct chevron, and, in the process, form distinct corrugations, which may be present even on internal moulds. Irregularly developed, weak dorsolateral nodes occur in a few specimens.

One of the notable features of *B. bailyi* (and other baculitids as well) is that it often occurs in great concentrations in single concretions, sometimes in more or less parallel arrangement. In some of these concretions, e.g. SAM-PCZ8390 from locality 13, the preservation is exquisite, with original shell material and protoconchs preserved (Figs 17A-B, 18A-B).

Early whorls with protoconchs are preserved in PCZ8390 (Fig. 17A), PCZ8390z (Fig. 18A), PCZ8390m (Fig. 18B), PCZ8390o, PCZ8390e and PCZ7213-4. The small diameter of the early coiled section is less than 0.5 mm, and explains why exposed protoconchs on fracture surfaces of concretions are

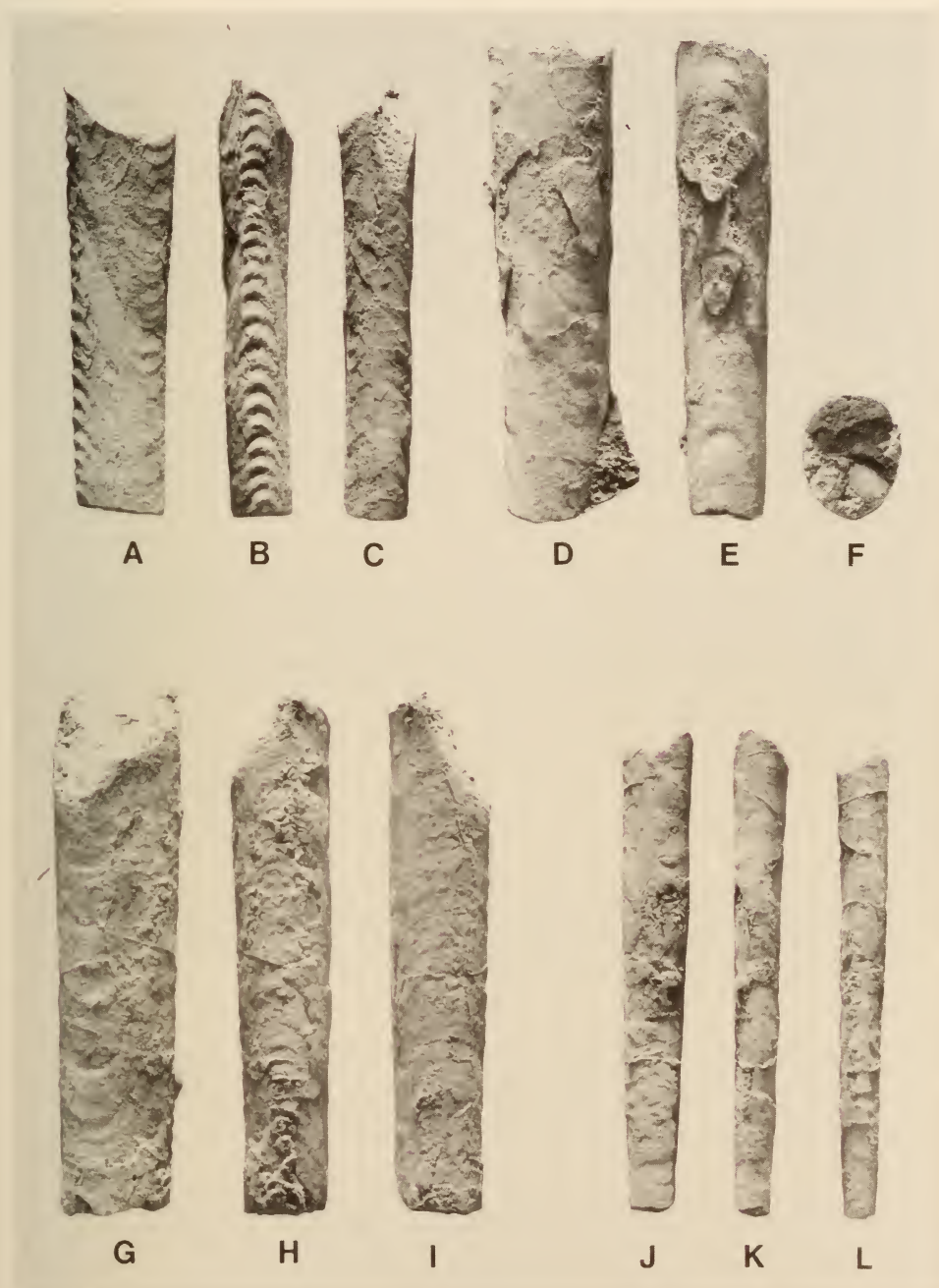


Fig. 15. *Baculites bailyi* Woods, 1906. A-C. SAM-PCZ8359, exact locality unknown, probably Mkweyane (Umkwelane Hill), Zululand. Note distinct ventral corrugation. D-F. SAM-PCZ8346. G-I. SAM-PCZ8345. J-L. SAM-PCZ8344 (microconch), all from locality 99, Zululand, St Lucia Formation, Santonian I or II. All $\times 1$.

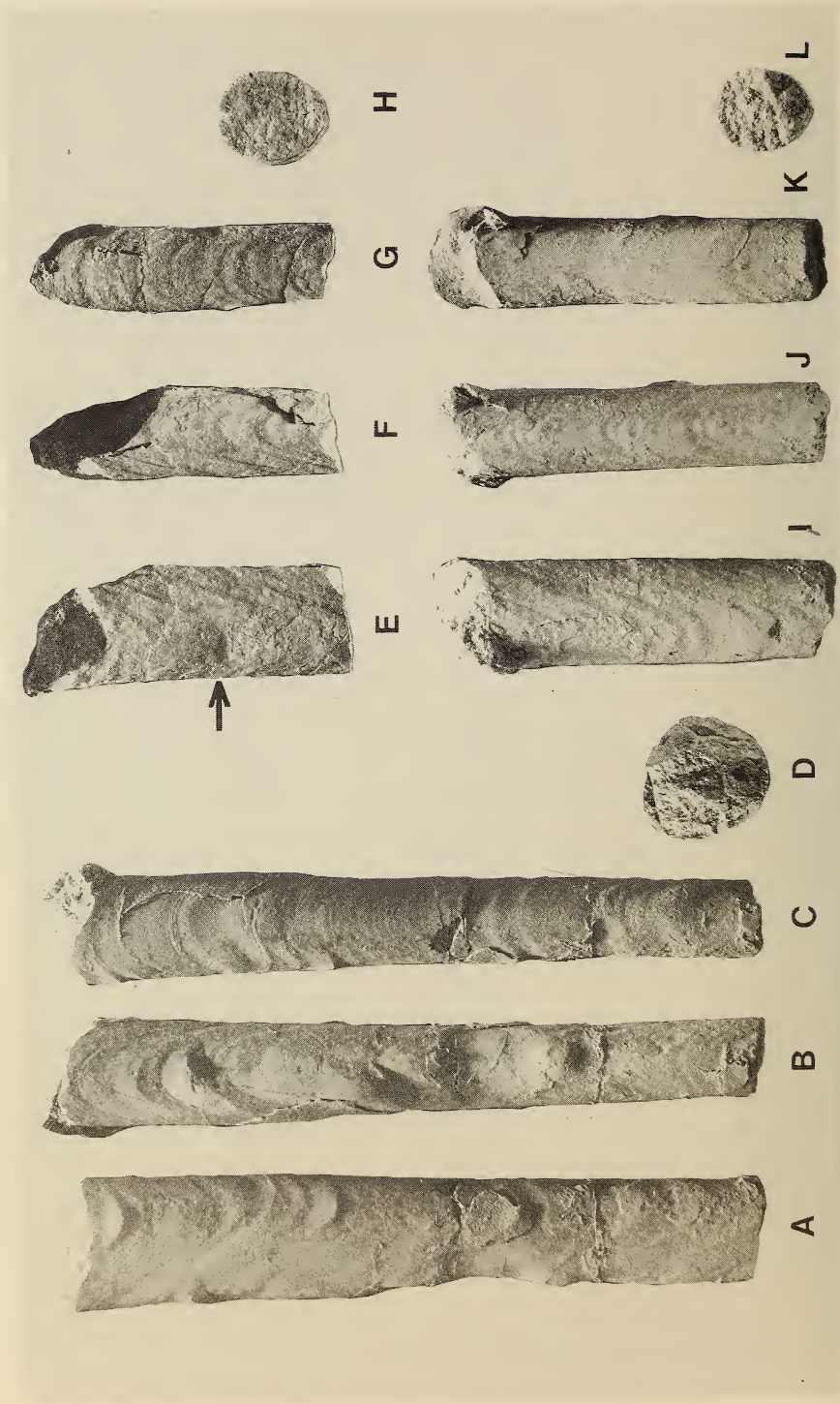


Fig. 16

extremely rare. A slight nick-point in the early shaft is also conspicuous. The presence and preservation of baculitids with protoconchs probably indicate very low energy levels in this depositional environment.

The whorl section is elliptical at very early diameters, c. 2 mm, and subsequently becomes ovoid, with a narrow to acute venter, and maximum whorl breadth just dorsal of mid-flank (Figs 19B–C, F, 20A–I, 21A–I, 22B–E). The whorl section is quite variable. In some, the section is distinctly tear-shaped, with a nearly acute venter, often accentuated by chevron ribbing over, and distinct corrugation of the venter. In others the venter may remain broadly rounded to large diameters, resulting in a near-circular whorl section.

Details of the ornament vary considerably, partly due to preservation. Ornament consists of fine striae which cross the whole periphery of the shell (Fig. 14J–Q), but are generally strongest on the ventral half of the flanks, where they curve and are strongly prorsiradiate. In some, the striae may be raised in sheaves on the dorsal part of the flanks, forming slight, crescentic, incipient tubercles (Fig. 14A–H). Over the venter some striae may thicken periodically, separated by weaker ones, or all may thicken. Both types of ornament produce distinct crenulation and chevron ribbing over the venter (e.g. Figs 15A–C, 16I–L, 23D–G, P–R).

In the majority of specimens, ornament on the body chamber and phragmocone is the same. In some, however, irregularly spaced dorsolateral nodes may appear on the body chamber. In PCZ8350 (Fig. 16A–D), albeit slightly pathologic, crescentic ribs appear on the body chamber. On PZC8353 (Fig. 34H–I) a single pair of tubercles occurs; on PCZ8387 (Fig. 34M–O) two pairs of distantly-spaced tubercles occur. We are not quite sure if these are, indeed, atypical forms of *B. bailyi* or weakly ornamented variants of *B. capensis*—we suspect the former.

Unfortunately preserved apertures are rare, but the disparate sizes of some apparently adult specimens (compare e.g. Figs 15G–I and 15J–L) suggest that the species may be dimorphic.

The suture lines (Figs 19A, D, 22A) of our specimens vary in details, but are relatively simple with open saddles and lobes.

Discussion

For several reasons, *B. bailyi* is difficult to interpret on the basis of the Pondoland material alone. Of the original type series, only the holotype and two very poorly preserved paratypes remain. The exact stratigraphic location of the holotype at the type section of the Mzamba Formation is unknown and, despite being amongst the first ammonites recorded from Mzamba, *B. bailyi* is extremely rare there. Most probably the biggest obstacle in referring smooth Coniacian and Santonian *Baculites* from Zululand and Pondoland to *B. bailyi*, as we had indeed done earlier (Kennedy & Klinger 1975: 278–279), is the seemingly atypical suture line of *B. bailyi* as figured by Woods (1906, pl. 44

Fig. 16 (see facing page). *Baculites bailyi* Woods, 1906. A–D. SAM-PCZ8350 (note irregular ornament on body chamber). E–H. SAM-PCZ8349 (arrow points to lateral tubercle). Both from locality 99, Zululand, St Lucia Formation, Santonian I or II. I–L. SAM-PCZ8356 from locality 100, Zululand, St Lucia Formation, Santonian I. All $\times 1$.

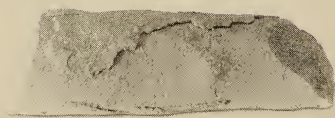
**A****B****C****D****E****F****G****H****I****J****K**

Fig. 17

(fig. 5)) (herein Fig. 13A) and taken from a specimen in the Griesbach collection. None of our smooth *Baculites* from Zululand have as narrow saddles as the specimen in Woods's figure.

The Griesbach collection was originally housed in the Hamburg Museum (Woods 1906: 275). This collection could not be traced and, according to Prof. C. Spaeth (letter 2.2.1992) was probably destroyed during aerial bombardment of the Museum in 1943. There is thus no way of ascertaining whether the suture line figured by Woods was indeed accurate or not. Unfortunately, the holotype, through being septate throughout, still has the shell preserved. Without damaging the shell, it is impossible to determine whether it has a suture like that of the material described here, or of the lost Griesbach specimen.

Woods (1906: 432) also mentioned that 'Several other specimens were collected by the (Cape of Good Hope Geological) Survey.' Only two of the Survey specimens (SAM-13103, 4822) could be traced in the collections of the S.A. Museum. These are poorly preserved internal moulds and do not show the sutures.

As mentioned above, *B. bailyi* is a rarity at Mzamba. All our specimens of *B. bailyi* from Mzamba were collected in the basal beds, where it occurs with *B. capensis*. Most of these specimens are small but we are reasonably confident that these are indeed consistently smooth *Baculites* and not merely smooth forms of *B. capensis*. Those specimens from which sutures could be traced, e.g. PCP6765 (Fig. 19A) and PCP8729 (Fig. 19E), show considerable variation in sutural details, but none are quite like Woods's figure.

Apart from our own material, the largest fossil collection from Mzamba to date was made by Van Hoepen in 1919 and is housed in the Transvaal Museum (Van Hoepen 1921). Unfortunately, no precise stratigraphic data are available for this collection; the locality is merely given as Mzamba Estuary. The Van Hoepen collection is of extreme interest in that it contains a baculitid assemblage that we had not encountered at the type section. Six of these baculites were tentatively referred to *B. bailyi* by Van Hoepen, 'There is, however, still an element of doubt' (Van Hoepen 1921: 18). These are all juvenile specimens with whorl sections varying from circular to elliptical. It is impossible to identify them any more precisely as *Baculites*. All the other baculitids were referred to *B. sulcatus* by Van Hoepen. Details of these are given below (p. 114). What is important, however, is that these differ from typical *B. sulcatus* from the uppermost beds at Mzamba, and can possibly be regarded as early forms connecting with *B. capensis* from the basal beds. Ornament in these specimens of *B. sulcatus* varies from individuals with extremely strong lateral nodes projected forwards over the flanks and over the venter as strong ribs and with

Fig. 17 (*see facing page*). *Baculites bailyi* Woods, 1906. A. SAM-PCZ8390. B. SAM-PCZ8390b. Parts of same concretion showing protoconchs. Both from locality 13, Zululand, St Lucia Formation, Coniacian II or III. C. SAM-PCZ8039. D-F. SAM-PCZ8367 from locality 99, Zululand, St Lucia Formation, Santonian I or II. G-H. SAM-PCZ8390j from locality 13, Zululand. I. SAM-PCZ8020 from locality 101, Zululand, St Lucia Formation, Santonian II or III. (Note weak tubercle.) J-K. SAM-PCZ8364b from locality 80, Zululand, St Lucia Formation, Coniacian V. Scale bar for size for A and B; D-F, I-K $\times 1$; G-H $\times 2$.

A
B

Fig. 18. *Baculites bailyi* Woods, 1906. A. SAM-PCZ8390z. Concretion crowded with juvenile specimens. B. SAM-PCZ8390m. SEM photograph of barrel-shaped protoconch and early straight shaft. From locality 13, Zululand, St Lucia Formation, Coniacian II or III. A $\times 1$; B $\times 25$.

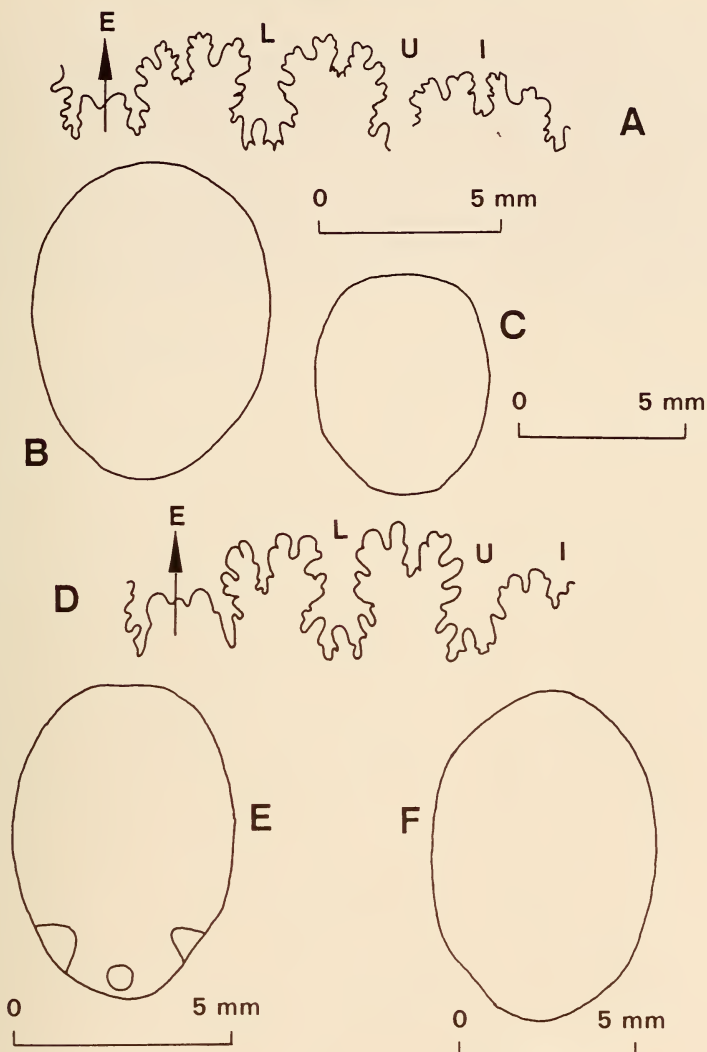


Fig. 19. *Baculites bailyi* Woods, 1906. Whorl section and suture lines. A-B. SAM-PCP6765. C-D. SAM-PCP6766. E. SAM-PCP8729. F. NMBD108. Venter in whorl section pointing downward. Scale bar for size.

numerous ventral intercalatories, to specimens with smooth flanks and only suggestions of ventral corrugations. The suture line of one of the latter (smooth specimens), TM 540m (Fig. 70C) is nearly identical to that figured by Woods of the specimen of *B. bailyi* in the (now lost) Griesbach collection. This suggests—but it is impossible to prove—that the suture line figured by Woods may possibly have been taken from a smooth form of *B. sulcatus*.

Three baculitids (Fig. 13F-K) dredged off the Natal South Coast (Klinger 1985) are derived from what are probably offshore equivalents of the Mzamba Formation. They occur in a faunal assemblage similar to that described from

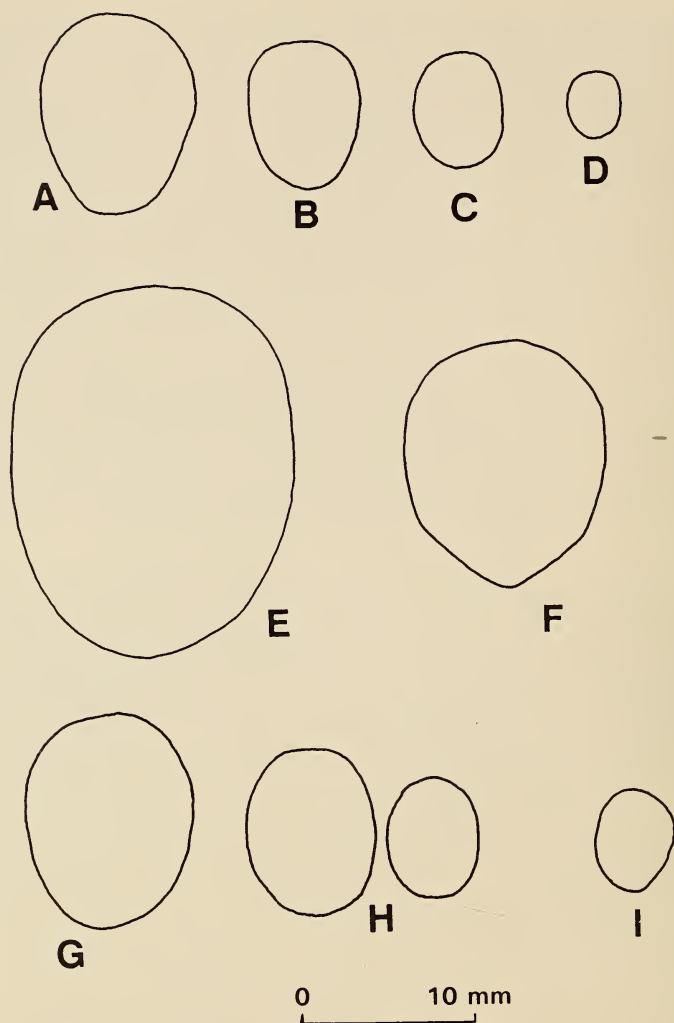


Fig. 20. *Baculites bailyi* Woods, 1906. Whorl sections.
 A-D. SAM-PCZ8710. E. SAM-PCZ9845. F. SAM-PCZ8356.
 G. SAM-PCZ8374. H. SASH28/3. I. SAM-PCZ9943.
 Venter pointing downward. Scale bar for size.

Mzamba by Van Hoepen (1920, 1921). As far as whorl section and lack of ornament is concerned, they are unmistakably *B. bailyi* when compared to the holotype. Unfortunately only parts of the suture are visible in two of the specimens but the tops of the saddles appear wider than in Woods's figure.

These rather inconclusive data from the type locality of *B. bailyi* indicate that the species is coeval with *B. capensis* in the Middle Santonian, and may occur as late as the early Campanian, where it is partly coeval with *B. sulcatus*. The suture line figured by Woods does not seem to be characteristic of typical *B. bailyi*. In all likelihood, it was either drawn incorrectly, or is from a smooth form of *B. sulcatus*.

This interpretation of *B. bailyi* seems to verify Matsumoto & Obata's (1963: 35), Ward's (1978: 1148) and Olivero's (1984: 57) records of this species from the Upper Santonian of Hokkaido, Upper Santonian to Lower Campanian of British Columbia and Lower Campanian of James Ross Island, respectively. Furthermore, none of the figured suture lines of their specimens has narrow saddles and lobes, as in Woods's figure. Matsumoto & Obata (1963: 37) also commented that the sutures of their specimens of *B. bailyi* differed from the Pondoland material. The two sutures illustrated by Matsumoto & Obata (1963, text-figs 88-89) also show minor differences in the width of the individual elements.

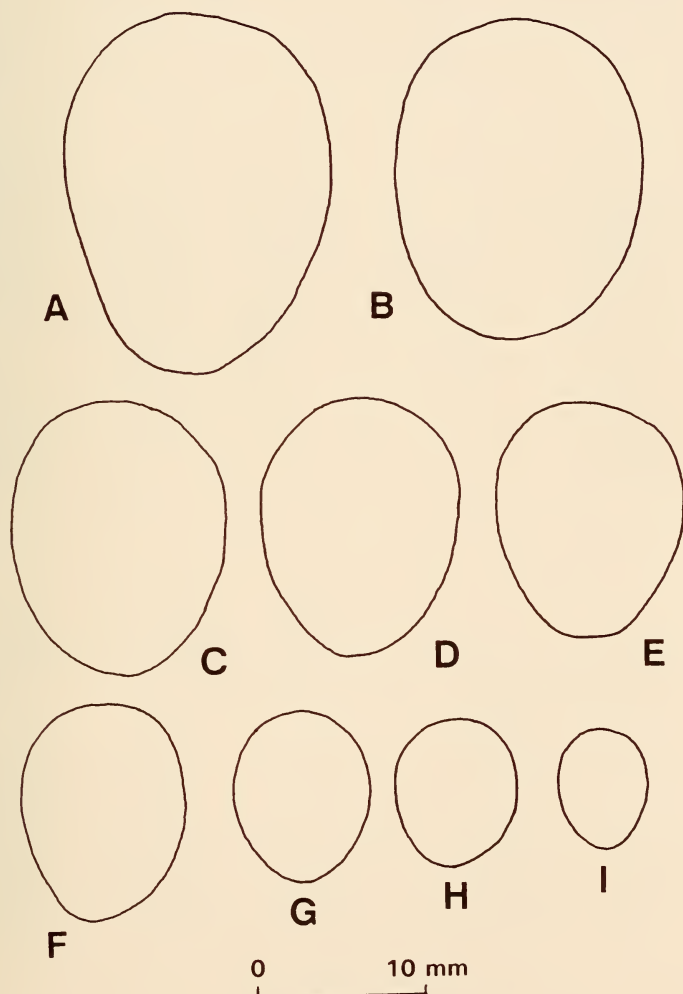


Fig. 21. *Baculites bailyi* Woods, 1906. A. Whorl sections. A. SAM-PCZ8389. B. SAM-PCZ8346. C. SAM-PCZ8345. D. SAM-PCZ8373. E. SAM-PCZ8347. F. SAM-PCZ8375. G. SAM-PCZ8384. H. SAM-PCZ8384. I. SASH135. Venter pointing downward. Scale bar for size.

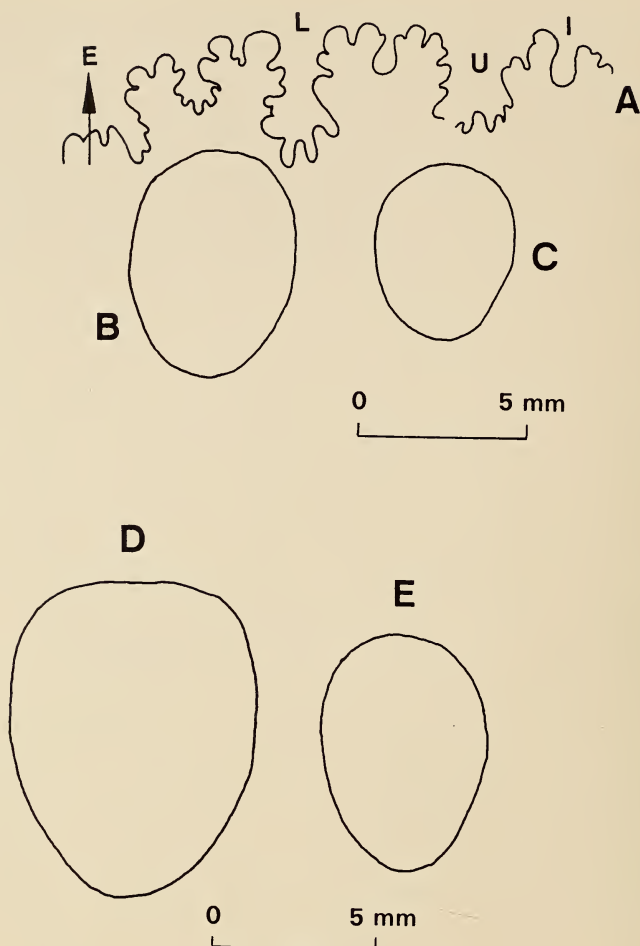


Fig. 22. *Baculites bailyi* Woods, 1906. Suture line and whorl sections. A-C. SAM-PCZ8390i. D-E. SAM-PCZ8390a. Venter in whorl section pointing downward. Scale bar for size.

Collignon (1969: 21, pl. 520 (fig. 2051)) confirmed the rarity of the species in Madagascar, where only two specimens are known, from the Lower Campanian. Earlier records of *B. bailyi* from the Santonian of the Montagne de Français (Madagascar) by Besairie (1930: 223, pl. 21 (figs 6-7)) are probably partially incorrect. One of these specimens (Besairie's fig. 6) has distinct dorsolateral ribbing and definitely does not belong here; the other is probably *B. bailyi*.

Fig. 23 (see facing page). *Baculites bailyi* Woods, 1906. A-C. SAM-PCZ8379. D-G. SAM-PCZ8354. H-I. SAM-PCZ8353. J-M. SAM-PCZ8355. Note lateral tubercle in H. N-O. SAM-PCZ12782, all from locality 98, Zululand, St Lucia Formation, Coniacian ?V. P-R. SAM-PCZ8016 from locality 96, Zululand, St Lucia Formation, Coniacian V or Santonian I. S-U. SAM-PCZ8390 from locality 13, Zululand, St Lucia Formation, Coniacian II-III. All $\times 1$.



Fig. 23

In contrast to Pondoland, *B. bailyi* is locally very common in Zululand, especially on the north-eastern part of the floodplain of the Hluhluwe River at Nkundusi, where it occurs in the uppermost Coniacian and/or Lower Santonian. Elsewhere in Zululand, *B. bailyi* first occurs in the second or third divisions of the Coniacian. Initially we thought that these smooth Coniacian specimens of *Baculites* were the same as *B. besairiei* from Madagascar. However, as discussed above, *B. besairiei* (including *B. roedereri* and *B. latelobatus*) is a synonym of *B. yokoyamai*. We admit that it is difficult to separate isolated specimens of *B. yokoyamai*, *B. bailyi* and smooth or juvenile *B. capensis*; identification is mainly by association. These three species have overlapping stratigraphic ranges and morphologies in the Coniacian, but they generally do not occur together. The whorl section of *B. yokoyamai* is predominantly elliptical, whereas that of *B. bailyi* is generally ovoid to circular. Completely smooth specimens of *B. capensis* are rare, but can generally be distinguished from *B. bailyi* by the more elliptical whorl section. Juvenile specimens of some early forms of *B. capensis*, where tuberculation only develops in late stages of growth—e.g. Figure 49J, are difficult to impossible to separate from *B. bailyi*.

It is equally difficult or impossible, on external morphology alone, to distinguish between *B. bailyi* and *Baculites* sp. aff. *B. rectus* (see p. 47). Both are completely smooth and have similar whorl sections. Suturally, however, they are totally different. Even small phragmocone fragments of *Baculites* sp. aff. *B. rectus* show the highly complex suture that immediately distinguishes it from *B. bailyi* as figured by Woods (1906), Matsumoto & Obata (1963), Ward (1978) or Olivero (1984).

Baculites uedae Matsumoto & Obata (1963: 40, pl. 20 (figs 5–7), pl. 21 (figs 1, 3, 6), text-figs 91–92, 121–129), from the Santonian of Hokkaido, appears indistinguishable from our Zululand *B. bailyi*. It is virtually identical to some Santonian microconchs of *B. bailyi* (see e.g. Fig. 15J–L) from Zululand and we suspect that they may be synonyms. According to Matsumoto & Obata (1963: 43), *B. bailyi* and *B. uedae* are nearly contemporary in Hokkaido but, in all cases except one, occur at different localities. This seems to fit the general pattern of *Baculites* distribution in Zululand, where individual variants of the same species are generally clustered at different localities but at the same stratigraphic level.

Baculites kirki Matsumoto (1959: 143, pl. 43 (figs 1–3), text-figs 53a–b, 54–57, 58a–b) from the Santonian of California and possibly Hokkaido (Matsumoto & Obata 1963: 65, pl. 18 (fig. 2), text-fig. 114) resembles some of our specimens of *B. bailyi* with an acute venter, but in that species a distinct rounded ventral keel develops. However, the specimens figured by Riccardi & Aguirre Urreta (1988, pl. 3 (figs 4–8)) as *Baculites* cf. *B. kirki* from the Santonian of Cerro Indice in Patagonia are indistinguishable from some of our *B. bailyi* with very narrow venters, e.g. NMB D1075/1, and are probably conspecific, as are probably the Santonian specimens from James Ross Island, figured by Olivero (1992, pl. 1 (figs 1–3)).

Baculites fuchsi Redtenbacher (1873: 134, pl. 30 (fig. 15); see also Summesberger 1979: 113, pl. 1 (figs 2–4), text-figs 2–3; Immel *et al.* 1982: 28, pl. 11 (fig. 8)), from the Santonian of the Gosau Beds of Austria, is indistinguishable

from *B. bailyi*. Unfortunately, the Austrian species is too poorly known for definite comments. However, the association of smooth *B. fuchsi* with nodose *B. incurvatus* in the Gosau Beds is remarkably similar to the Pondoland association of *B. bailyi* with *B. capensis*. Given more material, it is possible that these European species may prove to be senior synonyms of *B. bailyi* and *B. capensis* (see also p. 92 onwards).

Baculites nugssuaquensis Birkelund (1965: 48, pl. 4 (fig. 1), pl. 5 (figs 1–4), pl. 6 (figs 1–2), text-figs 35–41), from the Santonian of West Greenland, is a homoeomorph of *B. bailyi*. Some specimens of *B. nugssuaquensis* with smooth flanks and ventral corrugations (e.g. Birkelund 1965, pl. 6 (fig. 2)) are indistinguishable from similarly ornamented *B. bailyi*, e.g. PCZ8359 (Fig. 15A–C). This species, however, belongs to the northern extension of the U.S. Western Interior baculitid lineage and any resemblance is due only to convergence.

Occurrence

Middle Santonian to Lower Campanian of Pondoland, offshore Natal Coast, Coniacian II to Campanian I of Zululand, Lower Campanian of Madagascar, James Ross Island, Antarctica, Upper Santonian of Hokkaido and Upper Santonian to Lower Campanian of British Columbia.

Baculites sp. aff. *B. rectus* Marshall, 1926

Figs 24–26

Compare

- 1926 *Baculites rectus* Marshall, p. 154, pl. 19 (fig. 1), pl. 32 (figs 9–10).
- 1953 *Baculites* aff. *rectus* Marshall; Spath, p. 19, pl. 7 (fig. 2a–c).
- 1970 *Baculites rectus* Marshall; Henderson, p. 23, pl. 3 (figs 2–3), text-fig. 6.
- 1984 *Baculites rectus* Marshall; Olivero, p. 64, pl. 1 (figs 6–9), text-figs 1c, 2.

Material

SAM-PC5068, glauconitic concretion with numerous baculitid fragments, labelled 'Sugar Terminus Foundations, Durban—Donated'. This locality is probably the same as 'Maydon Wharf Sugar Terminal Site' referred to by Kennedy *et al.* (1973) and later (Kennedy & Klinger 1975: 282) as locality 5 of the Mzamba Formation, and dated as Santonian III and Campanian ?I; several horizons are clearly represented (Kennedy & Klinger 1975: 282).

Description

The concretion contains numerous baculitids with whorl heights ranging from c. 2 mm to more than 20 mm. The whorl section (Fig. 25E–F) is typically ovoid, in some with a very narrow venter. Different sizes of body chambers suggest dimorphism. The aperture is slightly flared. The body chambers are all smooth.



Fig. 24. *Baculites* sp. aff. *B. rectus* Marshall, 1926. A-B. Parts of same concretion, SAM-PC5068 from Maydon Wharf, Sugar Terminal site, locality 5, Mzamba Formation, imprecisely dated as Santonian III-Campanian I. Both $\times 1$.

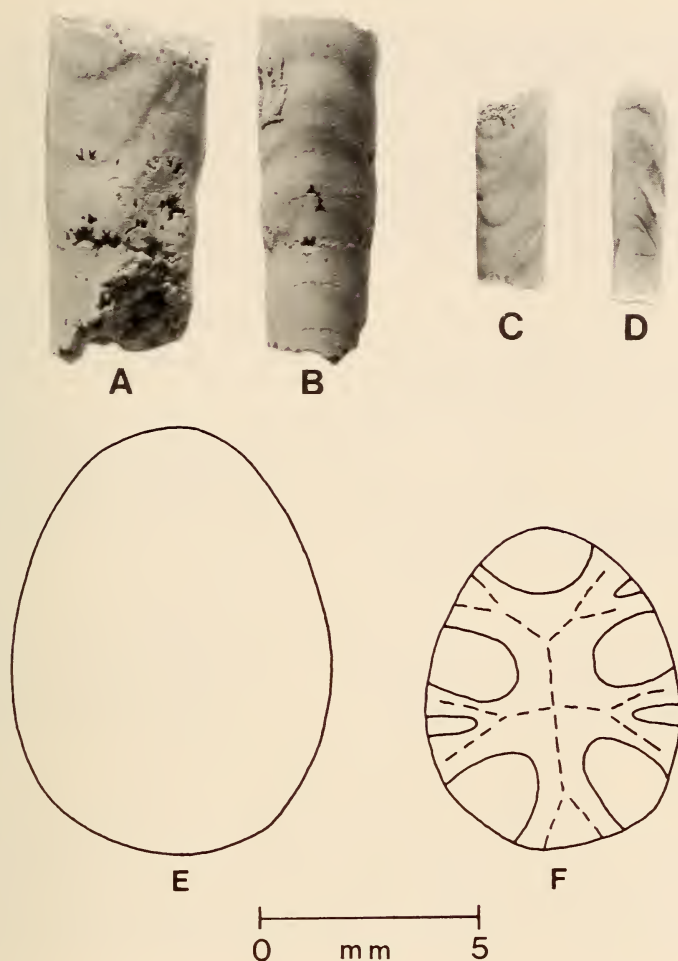


Fig. 25. *Baculites* sp. aff. *B. rectus* Marshall, 1926. A-B. SAM-PC5068b. C-D. SAM-PC5068a. A-B $\times 2$; C-D $\times 1$. E-F. Whorl sections. Venter pointing upward. Scale bar for size.

The majority of specimens are smooth, but several phragmocone fragments have low, rib-like swellings on the dorsal half of the flanks, and distinct, prorsiradiate sulci on the ventral half.

The suture is very complex, dendritic, with saddles and lobes with narrow stems and some phylloid folioles (Fig. 26).

Discussion

We initially thought that this was a concretion with *B. bailyi*, but the complex suture line immediately rules out this identification. Even small specimens can easily be distinguished as being totally different from *B. bailyi* on the basis of the sutural complexity. Unfortunately, we do not have a definite age



Fig. 26. *Baculites* sp. aff. *B. rectus* Marshall, 1926.
Suture line of SAM-PC5068. Scale bar for size.

for these specimens but we assume them to be younger than the highest beds exposed at the Mzamba Cliff, above the level of *B. sulcatus*. The association of an inflated pachydiscid nucleus possibly confirms this. At any rate, the degree of complexity of the suture line is greater than that of any of the other smooth baculitids yet known from southern Africa. The origins of this species are obscure. The similar whorl sections suggest derivation from *B. bailyi*,

Fig. 27 (see facing page). *Baculites capensis* Woods, 1906. A-C. SAM-4825b, paralectotype. D-H. SAM-4823, lectotype. I-K. SAM-PCP8753. L. SAM-PCP8050. All from the basal beds at locality 1, Pondoland, Transkei, Mzamba Formation, Santonian II. All $\times 1$.

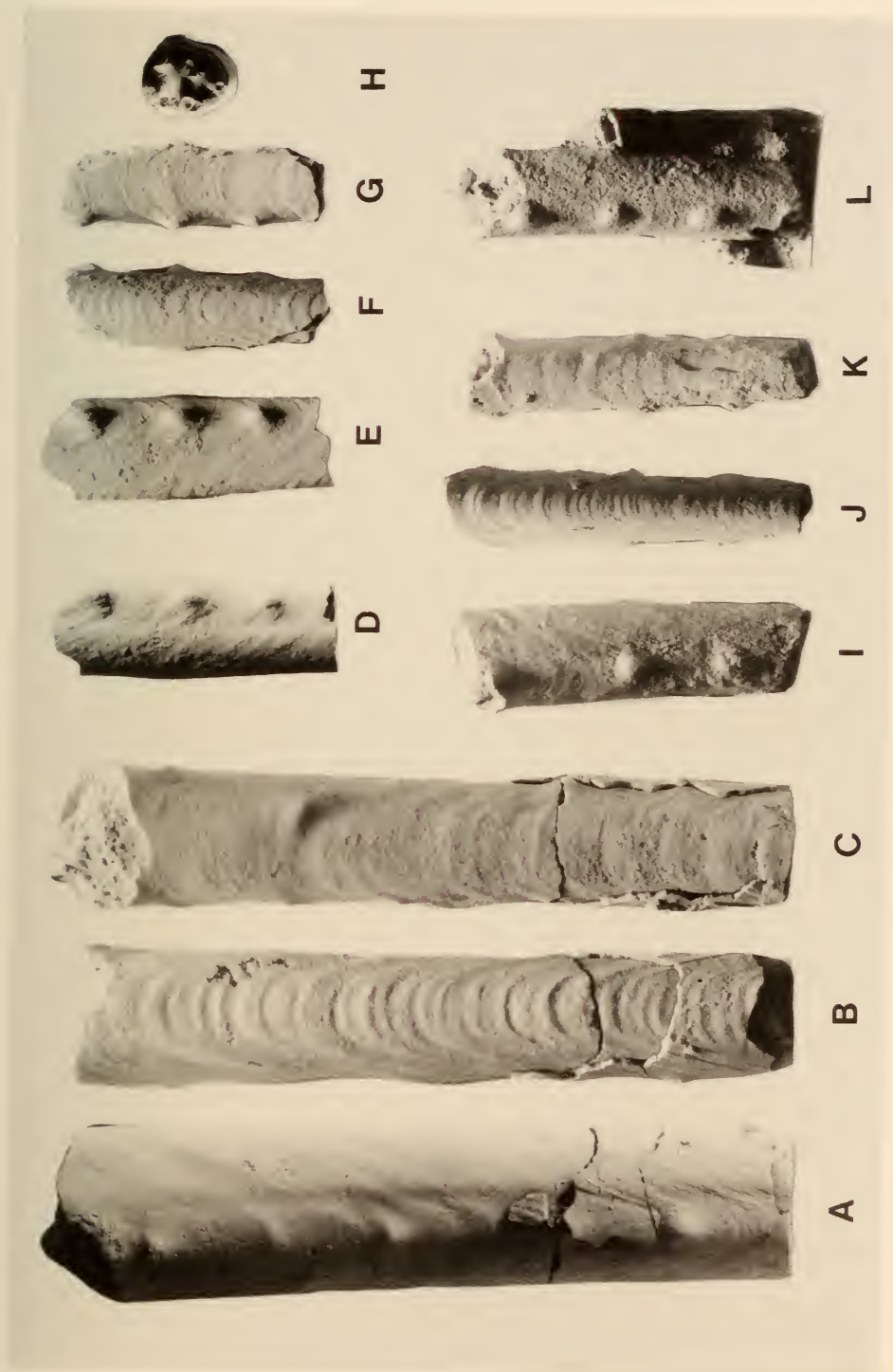


Fig. 27

associated with a sudden increase in sutural complexity. Alternatively, it could be regarded as an immigrant.

There are several smooth baculitid species with complex sutures with which our specimens can be compared.

Closest affinity seems to be with *B. rectus* Marshall (1926: 154, pl. 19 (fig. 1), pl. 32 (figs 9–10)), best known, but imprecisely dated, as Campanian–Maastrichtian from New Zealand (see also Henderson 1970: 23, pl. 3 (figs 2–3), text-fig. 6). Spath (1953: 19, pl. 7 (fig. 2a–e)) also tentatively recorded the species from Graham Land, Antarctica. Olivero (1984: 64, pl. 1 (figs 6–9), text-figs 1c, 2) also reported the species from the Campanian of James Ross Island, Antarctica. Collignon's (1977: 10) *Baculites* sp. indet. from the Campanian of New Caledonia may also belong here. None of these specimens has quite as complex a suture line as the Durban specimens—that figured by Olivero (1984, text-fig. 2) is the closest match. The suture figured by Spath (1953, pl. 7 (fig. 3)) has very narrow saddles, and resembles that of *B. bailyi* as figured by Woods (1906, pl. 44 (fig. 5)), but is more finely incised.

Baculites chicoensis Trask (1856: 85, pl. 2 (fig. 2)) from the Upper Campanian of California and British Columbia, and possibly southern Saghalin (Grabovskaya 1984) has a comparable complex suture line, but the whorl section is different—an incipient ventral keel appears in later growth stages. *Baculites chicoensis yezoensis* Matsumoto & Miyauchi (1984: 70, pl. 25 (figs 1–5), text-figs 11B–C) from the Lower Campanian of Hokkaido is closer to the Durban specimens in retaining a narrow but not perceptibly keeled venter, as in the nominate subspecies.

Baculites rex Anderson (1958: 191, pl. 49 (fig. 2)) from the Upper Campanian and Maastrichtian of California, British Columbia and Hokkaido has a more 'lytoceratine' or jagged suture and apparently grows to enormous size, as the name implies.

Baculites hochstetteri Liebus (1902: 119, pl. 6 (figs 4–6)), imprecisely dated as Upper Senonian of the Silesian Carpathian region, has sutures indistinguishable from our specimens. Unfortunately, this species is known only by the figured syntypes and further comparisons are impossible. The types, originally housed in Munich are lost, presumably destroyed during World War II.

Baculites regina Obata & Matsumoto (1963: 85, pl. 22 (figs 3–6), pl. 23 (figs 1–2), pl. 24 (figs 1–5), pl. 25 (figs 3–5), pl. 27 (figs 1, 6–7, 9), text-figs 191–196, 200–214) from the Campanian of Honshu, has a similarly complex suture line, but the adult, subpentagonal whorl section is immediately distinctive.

Baculites duharti Hünicken (in Hünicken *et al.* 1975: 116, pl. 1 (figs 1–4), pl. 2 (figs 1–2), pl. 3 (figs 5–8), text-figs 2a–d, 3a–c, 4–5)), from the Middle and/or Upper Campanian of Tierra del Fuego, and also from the Middle Campanian of Zululand (p. 178), is superficially similar to *Baculites* sp. aff. *B. rectus*, but has a much simpler suture line, and the elliptical whorl section typical of the *B. capensis* group.

Occurrence

Campanian s.l. of Durban.

Baculites capensis Woods, 1906
Figs 27–33, 34A–L, ?34M–R, 35–54

- 1906 *Baculites capensis* Woods, p. 342, pl. 44 (figs 6–7).
 1907 *Baculites vagina* Forbes; Boule, Lemoine & Thevenin, p. 65(45), pl. 15 (fig. 3–3a).
 1907 *Baculites* sp. Crick, p. 240.
 1921 *Baculites capensis* H. Woods; Spath, p. 257, pl. 24 (figs 6–7).
 1921 *Baculites* sp. aff. *capensis* H. Woods; Spath, p. 258.
 1921 *Baculites* cf. *aspero-anceps* Lasswitz; Spath, p. 259, pl. 24 (figs 4, 4a).
 1921 *Baculites* cf. *brevicosta* Schlüter; Spath, p. 260, pl. 24 (figs 5, 5a).
 1921 *Baculites* sp. cf. *sulcatus* Baily; Spath, p. 260.
 1922 *Baculites capensis* Woods; Spath, p. 146.
 1923 *Baculites capensis* Woods; Spath, p. 13, text-fig. 3d.
 ? 1925 *Baculites* sp. ind. Spath, p. 31, pl. 1 (fig. 1).
 ? 1930 *Baculites Bailyi* Woods; Besairie, p. 223 (pars), pl. 21 (fig. 6) only.
 1931 *Baculites* cf. *aspero-anceps* Lasswitz; Collignon, p. 22, pl. 3 (figs 7, 7a), pl. 9 (fig. 12).
 1931 *Baculites* aff. *capensis* Woods; Collignon, p. 22, pl. 3 (fig. 6).
 1931 *Baculites* cf. *brevicosta* Schlüter; Collignon, p. 34, pl. 5 (fig. 1, 1a), pl. 9 (fig. 13).
 1931 *Baculites Boulei* Collignon, p. 35, pl. 5 (fig. 2, 2a), pl. 9 (fig. 14).
 1932 *Baculites capensis* Woods; Besairie, p. 50.
 1936 *Baculites capensis* Woods; Venzo, p. 116 [58].
 1936 *Baculites capensis* Woods var. *umsinenensis* Venzo, p. 116 [58], pl. 10 [6] (figs 11–12).
 1958 *Baculites buttensis* Anderson, p. 191, pl. 49 (fig. 6, 6a, 6b).
 1958 *Baculites* aff. *B. capensis* Woods; Anderson, p. 192, pl. 48 (fig. 8, 8a).
 1959 *Baculites schencki* Matsumoto, p. 113, pl. 32 (figs 1a–c, 2a–c, 3a–b, 4a–b, 5a–c, 6a–c), text-figs 12a–b, 13a–c, 14a–b, 15–21, 22a–b, 23a–c, 24–25.
 1959 *Baculites boulei* Collignon; Matsumoto, p. 118, pl. 32 (fig. 7a–c), pl. 33 (figs 4a–c, 5a–b, 6a–d, 7a–b), text-figs 27a–b, 28–32.
 1959 *Baculites capensis* Woods; Matsumoto, p. 121, pl. 33 (figs 1a–d, 2a–c, 3a–b), pl. 45 (figs 1a–d, 2a–d, 3a–d, 4a–d), text-figs 33a–b, 34a–b.
 1963 *Baculites capensis* Woods; Matsumoto & Obata, p. 47, pl. 14 (fig. 2), pl. 15 (figs 3–5), pl. 19 (fig. 2), text-figs 95–96, 147–151.
 1966 *Baculites capensis* Woods; Collignon, p. 6, pl. 457 (fig. 1862).
 1966 *Baculites capensis* Woods var. *tenuetuberculata* Collignon, p. 6, pl. 457 (figs 1863).
 1966 *Baculites malagasyensis* Collignon, p. 7, pl. 457 (fig. 1865).
 non 1973 *Baculites* sp. group of *B. capensis* Woods; Kennedy & Klinger, p. 101, pl. 4 (figs 1–5), pl. 5 (fig. 1a–d), pl. 6 (figs 4–5). (= *B. vanhoeffeni*)
 1977 *Baculites capensis* Woods; Klinger & Kennedy, p. 71, figs 2A–F, 3G.
 ?non 1988 *Baculites capensis* Woods; Cooper, p. 210, fig. 1G–I.
 1991b *Baculites capensis* Woods; Kennedy & Cobban, p. 182, figs 6: 4.; 8: 1–8; 10: 7–10, 12–14; 12: 2,5.

Types

Woods based this species on at least four syntypes, which survive in the collections of the South African Museum. Lectotype, by subsequent designation of Matsumoto & Obata (1963: 48), is the smaller of the two specimens figured by Woods (1906, pl. 44 (fig. 6a–b)), from an unknown horizon at the type section of the Mzamba Formation at the Mzamba Estuary, Transkei, South Africa, SAM–4823—herein refigured as Figure 27D–H. Paralectotypes are SAM–4824, 4825 and 4825b, all from the same locality.

Material

We have several hundred catalogued and uncatalogued specimens from the following localities:

- (1) Basal beds and foreshore exposures at locality 1 at the Mzamba River Estuary, Pondoland, Mzamba Formation, Santonian II.
- (2) Locality 6, Zululand, St Lucia Formation, Santonian II–III to Campanian I.
- (3) Locality 15, Zululand, St Lucia Formation, Coniacian IV.
- (4) Locality 16, Zululand, Coniacian ?III.
- (5) Bed B at locality 22, Zululand, St Lucia Formation, Coniacian IV.
- (6) Locality 24, Zululand, St Lucia Formation, Coniacian II–V.
- (7) Locality 26, Zululand, St Lucia Formation, ?Santonian.
- (8) Locality 72, Zululand, St Lucia Formation, Coniacian III.
- (9) Locality 73, Zululand, St Lucia Formation, Coniacian IV–V, ?Santonian I.
- (10) Locality 80, Zululand, St Lucia Formation, Coniacian V.
- (11) Locality 83, Zululand, St Lucia Formation, Coniacian IV.
- (12) Locality 85, Zululand, St Lucia Formation, Santonian I.
- (13) Locality 88, Zululand, St Lucia Formation, Coniacian IV–V, ?Santonian I.
- (14) Localities 89 and 90, Zululand, St Lucia Formation, Coniacian IV.
- (15) Locality 91, Zululand, St Lucia Formation, Coniacian IV or V.
- (16) Locality 92, Zululand, St Lucia Formation, Coniacian II and III.
- (17) Locality 93, Zululand, St Lucia Formation, Coniacian II.
- (18) Locality 94, Zululand, St Lucia Formation, Coniacian V–Santonian I.
- (19) Locality 98, Zululand, St Lucia Formation, Coniacian ?V.
- (20) Field locality H51, Mpisene Creek, east of Nyalazi River Trading Store, Zululand, St Lucia Formation, ?Santonian.
- (21) Field locality H40, exposure at pump house on Nyalazi River, west of Nyalazi River Trading Store, Zululand, St Lucia Formation, Campanian ?I.

Dimensions

A full list of dimensions is given in the appendix.

Max Wb (mm)	MxWb/MxWh	MnWb/MnWh	Ti	Tubs/Wh
0–4.9	0.63	0.6	7.5	2
5–9.9	0.73	0.74	6.48	2.57
10–14.9	0.73	0.71	3.92	2.29
15–19.9	0.75	0.75	5.64	2.18
20–21	0.77	0.73	—	2

Fig. 28 (see facing page). *Baculites capensis* Woods, 1906. A. Plaster cast of exposed surface of basal beds of Mzamba Formation on south side of the Mzamba River estuary. B–E. SAM-4824, paralectotype figured by Woods (1906, pl. 44 (fig. 7a–c)). F. SAM-4825, unfigured paralectotype. All from the basal beds of the Mzamba Formation at locality 1, Pondoland, Transkei, Santonian II. All $\times 1$.

Fig. 29 (see overleaf). *Baculites capensis* Woods, 1906. All specimens from the basal beds of the Mzamba Formation at locality 1, Pondoland, Transkei, to illustrate the variation in ornament. A–C. SAM-PCP8664. D. SAM-PCP8665. E. SAM-PCP8755. F–H. SAM-PCP8663. I. SAM-PCP8360. J. SAM-PCP8052. K. SAM-PCP8053. L. SAM-PCP8051. M. SAM-PCP8054. N–P. SAM-PCP8241. All $\times 1$.

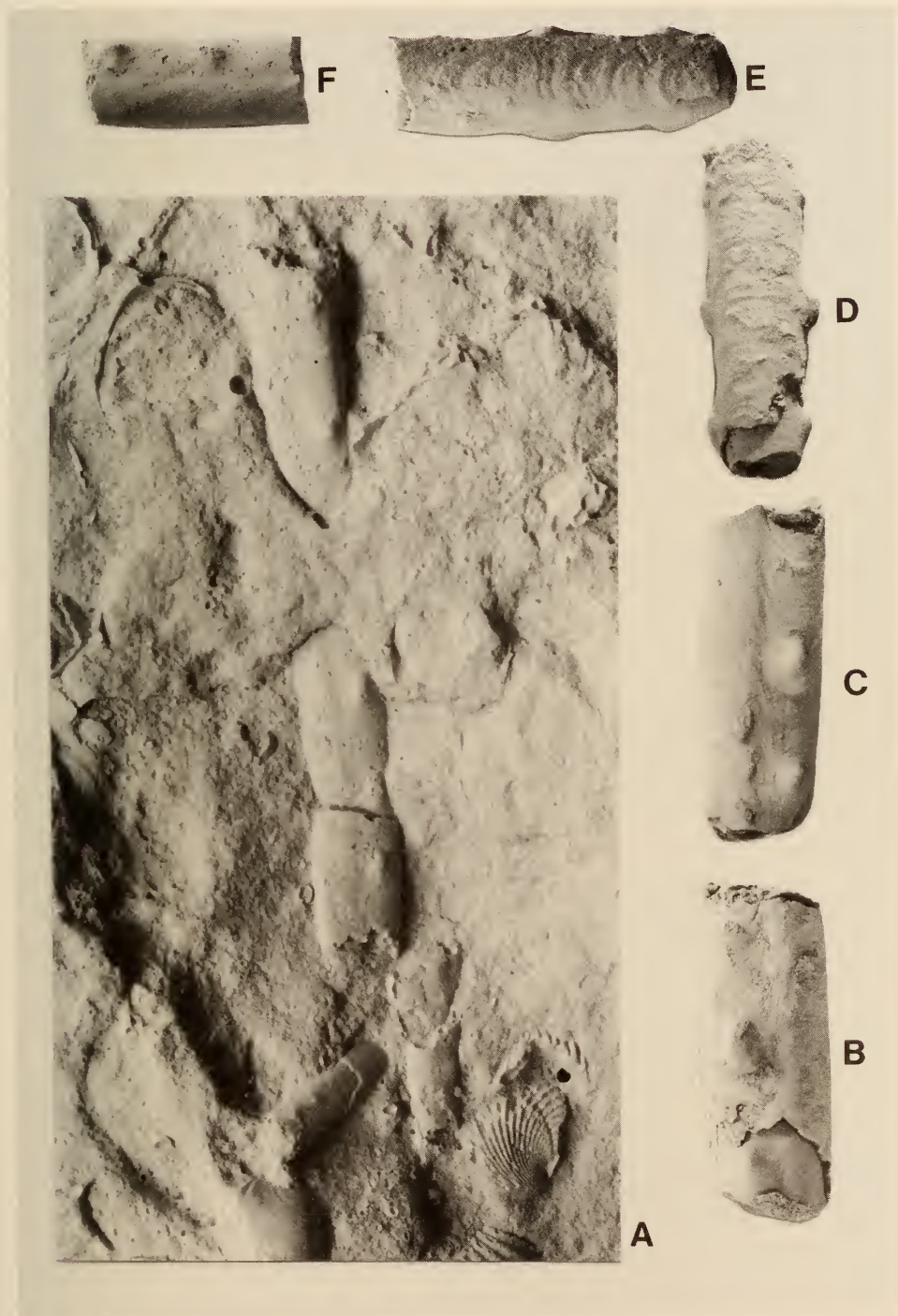


Fig. 28

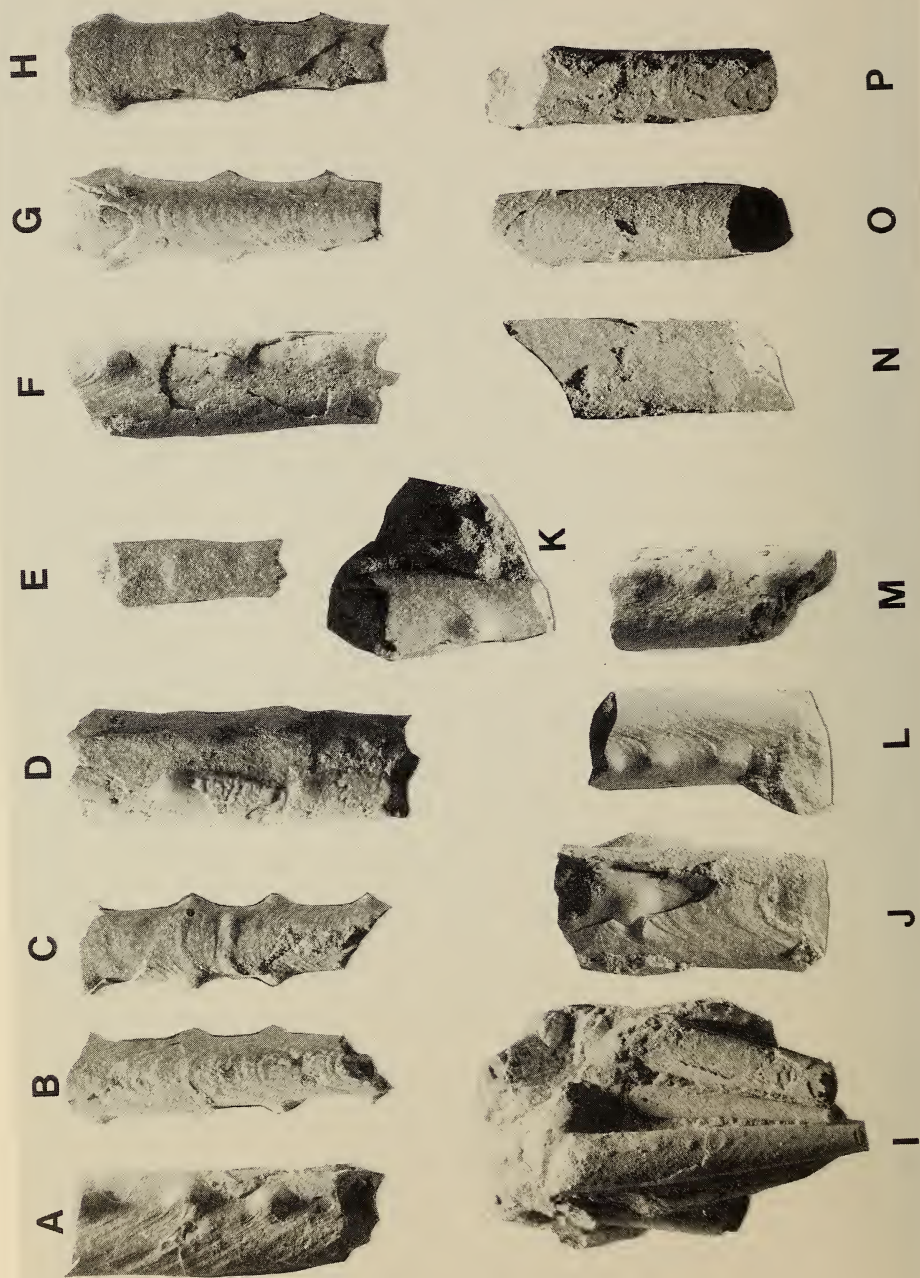


Fig. 29

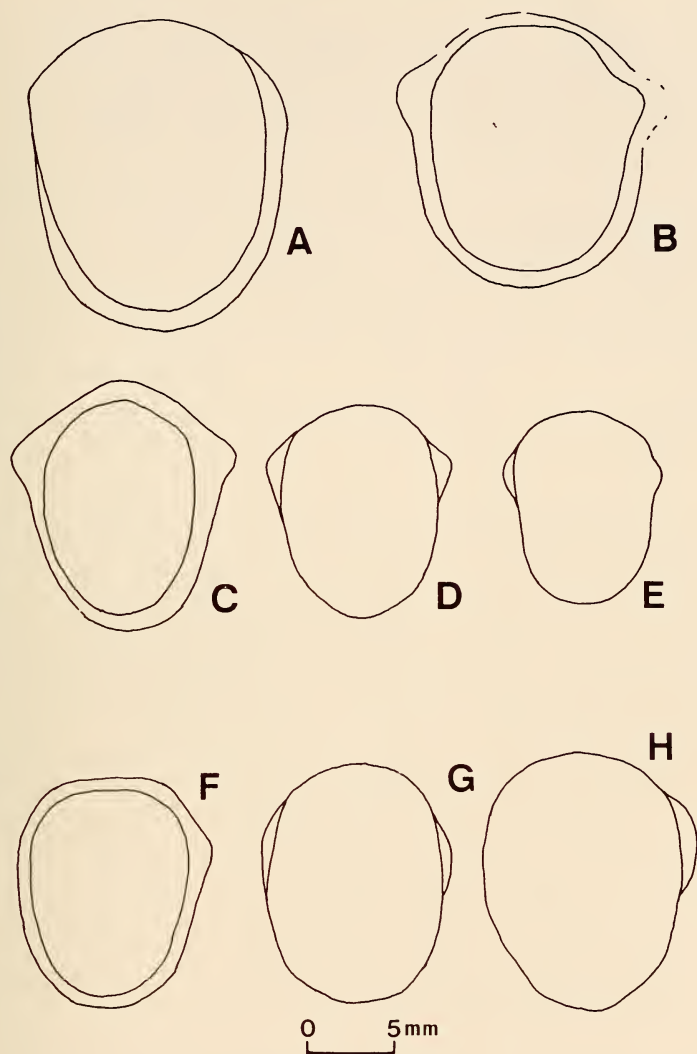


Fig. 30. *Baculites capensis* Woods, 1906. Whorl sections of type series and topotype material. A-B. SAM-4824. C-D. SAM-4823 (lectotype). E. SAM-PCP8754. F. SAM-PCP8756. G. SAM-PCP8662. H. SAM-PCP8665. Venter pointing downward. Scale bar for size.

Description

This is the most common baculitid in Zululand, Natal and Pondoland, and is very variable, as here interpreted. In order to illustrate the variation of the species, we first describe the types and topotype material collected at the type locality, the Mzamba River estuary in Pondoland.

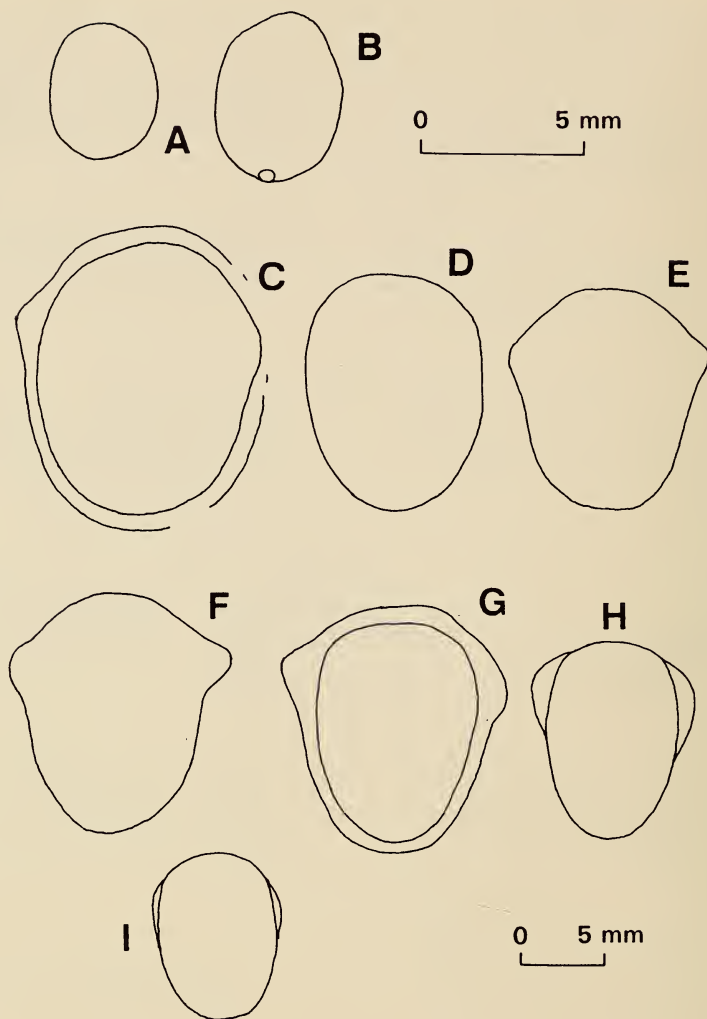


Fig. 31. *Baculites capensis* Woods, 1906. Whorl sections of specimens from the type locality. A. SAM-PCP8360/10. B. SAM-PCP8360/13. C. SAM-PCP8052. D. SAM-PCP8241. E. SAM-PCP8051. F. SAM-PCP8644. G. SAM-PCP8663. H. SAM-PCP8663. I. SAM-PCP6767. Venter pointing downward. Scale bar for size.

Description of type specimens. The lectotype, SAM-4823 (Fig. 27D-H) is part of a phragmocone, partially filled with sparry calcite and glauconitic silt. SAM-4824 (Fig. 28B-E) is non-septate, and, at the larger end, has part of the aperture preserved. SAM-4825 (Fig. 28F) is a fragment of which the one flank is corroded. SAM-4825b (Fig. 27A-C) is a large body chamber and, to date, the largest specimen of *B. capensis* recorded from the Mzamba Formation.

Woods's figures of the lectotype and paralectotype are quite accurate and show the characteristic features of the species—an elliptical whorl section with

the venter as wide as, or only slightly narrower than the dorsum, and parallel flanks with a shallow, longitudinal depression situated immediately ventral of the tubercles. This depression is very shallow, as different angles of illumination of the lectotype illustrate (Fig. 27D-E). In the lectotype (SAM-4823) and paralectotypes (SAM-4824, 4825) the tubercles are characteristically pinched and clavate.

Paralectotype SAM-4825b (Fig. 27A-C) is part of an internal mould of a body chamber. As mentioned above, it is the largest specimen of *B. capensis* known to us from the Mzamba Formation and is obviously a macroconch. Here the tubercles are much weaker than on the lectotype and conical to bullate, rather than clavate. The longitudinal depression at midflank is not as prominent as in the other specimens. Distinct, forwardly projected ribs are visible on the venter (on the internal mould).

Descriptions of topotype Pondoland material. We have several specimens of *B. capensis*, all from the basal beds of the Mzamba Formation, at Mzamba Cliff.

Juveniles. The juveniles are fortuitously preserved in a small concretion (SAM-PCP8360) containing about 20 individuals (Fig. 29I) and the impressions of others. The smallest diameter preserved is 1.7 mm. The whorl section in the early stages is oval (Fig. 31A-B), with the venter as wide, or only slightly narrower than the dorsum. The appearance of tubercles is variable. On PCP8360/10 (Fig. 29I), an internal mould, the surface of the flanks is perfectly smooth up to a whorl height of about 5 mm, when weak, crescentic dorsolateral tubercles start appearing. Faint ribbing over the venter starts appearing at a slightly earlier stage. In other, larger specimens, the flanks are still smooth, ornamented by faint striae only. In PCP8360/3 the venter is distinctly crenulated on the internal mould and the flanks bear low, rounded tubercles.

Adult stage. The whorl section shows some variation, depending on whether seen in nodal or internodal view, and also whether taken on an internal mould or on the external surface of the shell (Figs 30-31). They are generally near-elliptical, with parallel flanks and the venter only slightly narrower than the dorsum. In some, however, e.g. PCP8644 (Fig. 31F), the whorl section is trigonal, with a narrowly rounded venter. In others, the venter may be slightly fastigiate, e.g. SAM-4823 (Fig. 27H).

The size, shape and spacing of the tubercles varies considerably; again this is partially determined by whether the shell is preserved, or whether seen on the internal mould. Typical ornament associated with the name *B. capensis* consists of longitudinally elongated, either oblongly rounded or dorsoventrally pinched tubercles, situated near the dorsal quarter of the flanks, e.g. lectotype SAM-4823 (Fig. 27D-E), paralectotype SAM-4824 (Fig. 28B-C)—this shows the tuberculation on the internal mould and in shelly preservation, and Figure 28A—a plaster cast of a large phragmocone. These longitudinally elongated tubercles are generally bordered at mid-flank by a very shallow, longitudinal depression. This depression is hardly visible in transverse (whorl section) view, but is quite clear under oblique, low lighting. Compare, for example, Figure 27D-E of the same (lectotype) specimen under different

illumination. In typical *B. capensis*, the spacing of tubercles numbers about two per whorl height.

In some specimens, the tubercles are distinctly conical to rounded, e.g. SAM-8753 (Fig. 27I-K) or PCP8050 (Fig. 27L), and in others low and rounded, e.g. PCP8052 (Fig. 29J) and PCP8665 (Fig. 29D). In a few, e.g. PCP8662 or PCP8241 (Fig. 29N-P), the tubercles are extremely feebly developed, so as to be near-absent. In PCP8054 (Fig. 29M) the tubercles are closer and irregularly spaced.

The surface of the shell bears fine striae, e.g. PCP8050 (Fig. 27L), and PCP8052 (Fig. 29J). In some, e.g. PCP8664 (Fig. 29A-C), these are quite strongly developed, and even visible on internal moulds, e.g. SAM-4825b (Fig. 27A-C). Ventral corrugations are variably developed, ranging from absent to extremely prominent, even on internal moulds.

Parts of the aperture are preserved in paralectotype SAM-4824 (Fig. 28C); paralectotype SAM-4825b (Fig. 27A-C)) is a larger body chamber; both are perfectly straight. PCP8050 (Fig. 27L) is a smaller, slightly curved body chamber. The former two are probably macroconchs; the latter a microconch.

Description of Zululand material. In Zululand, *B. capensis* may be defined as a predominantly nodose baculitid with elliptical to ovoid whorl section; size and shape of nodes varies, from absent, through weakly conical to strongly conical, weakly to strongly crescentic, longitudinally elongated, obliquely elongated, close, widely or irregularly spaced; some with shallow longitudinal depression at midflank. Suture simple.

As can be deduced from this definition, the material is extremely variable (see e.g. Fig. 33) and several morphotypes, based primarily on the presence and shape of the tubercles, can be recognized. Some of these morphotypes appear to be related to stratigraphic occurrence—others are conspicuous at particular

Fig. 32 (*see facing page*). *Baculites capensis* Woods, 1906. Two specimens to illustrate extremes of variation in ornament. A-C. NMBD1052/1 from locality 72, Zululand, St Lucia Formation, Coniacian III. D-F. SAS A2101 from locality 73, Zululand, St Lucia Formation, Coniacian IV-V. Both $\times 1$.

Fig. 33 (*see overleaf*). *Baculites capensis* Woods, 1906. Diverse specimens to illustrate variation in strength and shape of tuberculation. A-C. SAM-PCZ11999 from locality 91, Zululand, St Lucia Formation, Coniacian IV or V. D. SAM-PCZ12000. E. SAM-PCZ8676, both from locality 83, Zululand, St Lucia Formation, Coniacian IV. F. SAM-PCZ12001 from locality 85, Zululand, St Lucia Formation, Santonian I. G. SAM-4832 from locality 1, Pondoland, Mzamba Formation, Santonian II. H. NMBD1028/3. I. SAS A361. J. SAS A333. L. SAM-PCZ8013, all from locality 72, Zululand, St Lucia Formation, Coniacian III. K. SAS Z1795f. M. SAS Z1795g. Both from locality 85. All $\times 1$.

Fig. 34 (*see overleaf*). A-L. *Baculites capensis* Woods, 1906. A-C. SAM-5454. D-F. SAM-5480. G. SAM-5458. H. SAM-5486. I. SAM-5461. J. SAM-5472. K. SAM-PCZ8674b. L. SAS A1610a. All from Mkweyane ('Umkwelane Hill'), probably locality 10, Zululand, St Lucia Formation. All specimens with 'brevicosta' or 'schencki' type of ornament. M-R. Two specimens with atypical, widely spaced tubercles. It is uncertain if these are atypical *B. capensis* (form 12) or nodose variants of *B. bailyi*. M-O. SAM-PCZ8387. P-R. SAS PCZ8349. Both from locality 98, Zululand, St Lucia Formation, Coniacian V, associated with typical *B. bailyi* fauna. All $\times 1$.

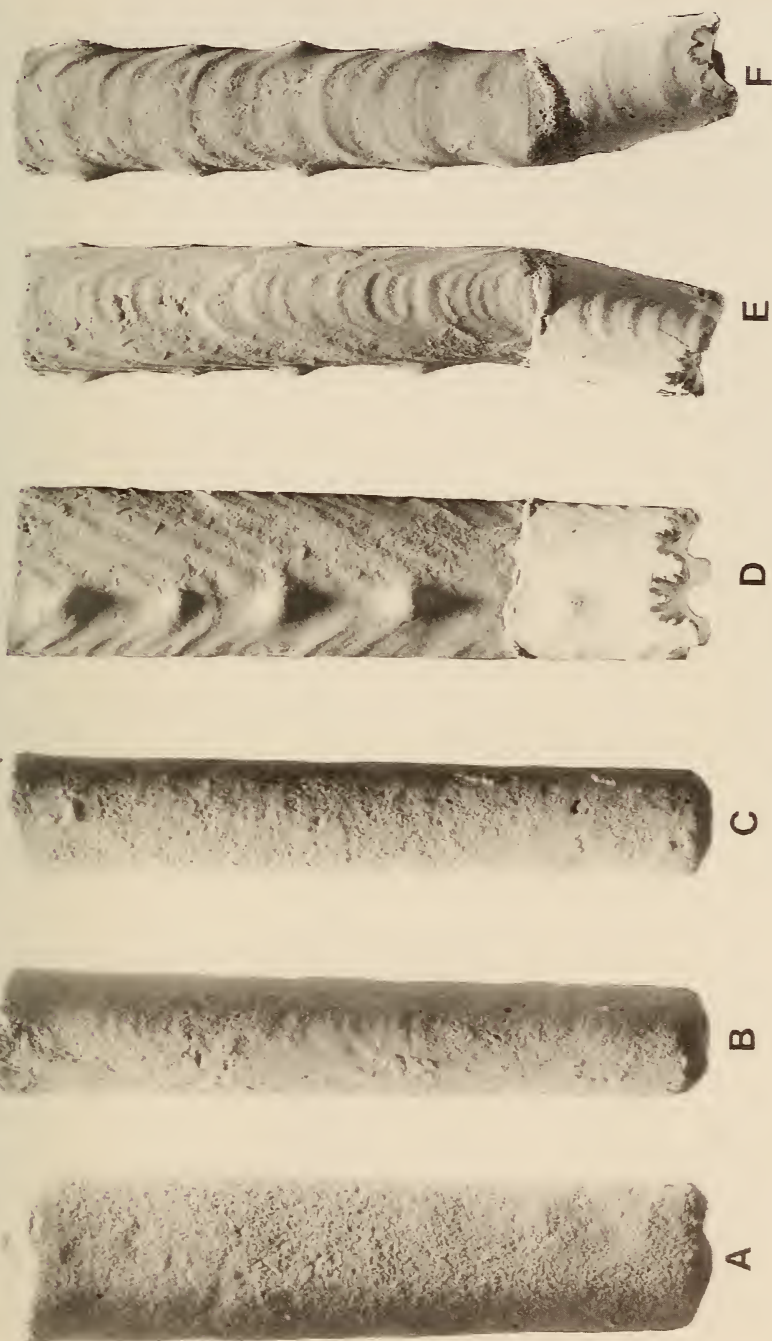


Fig. 32

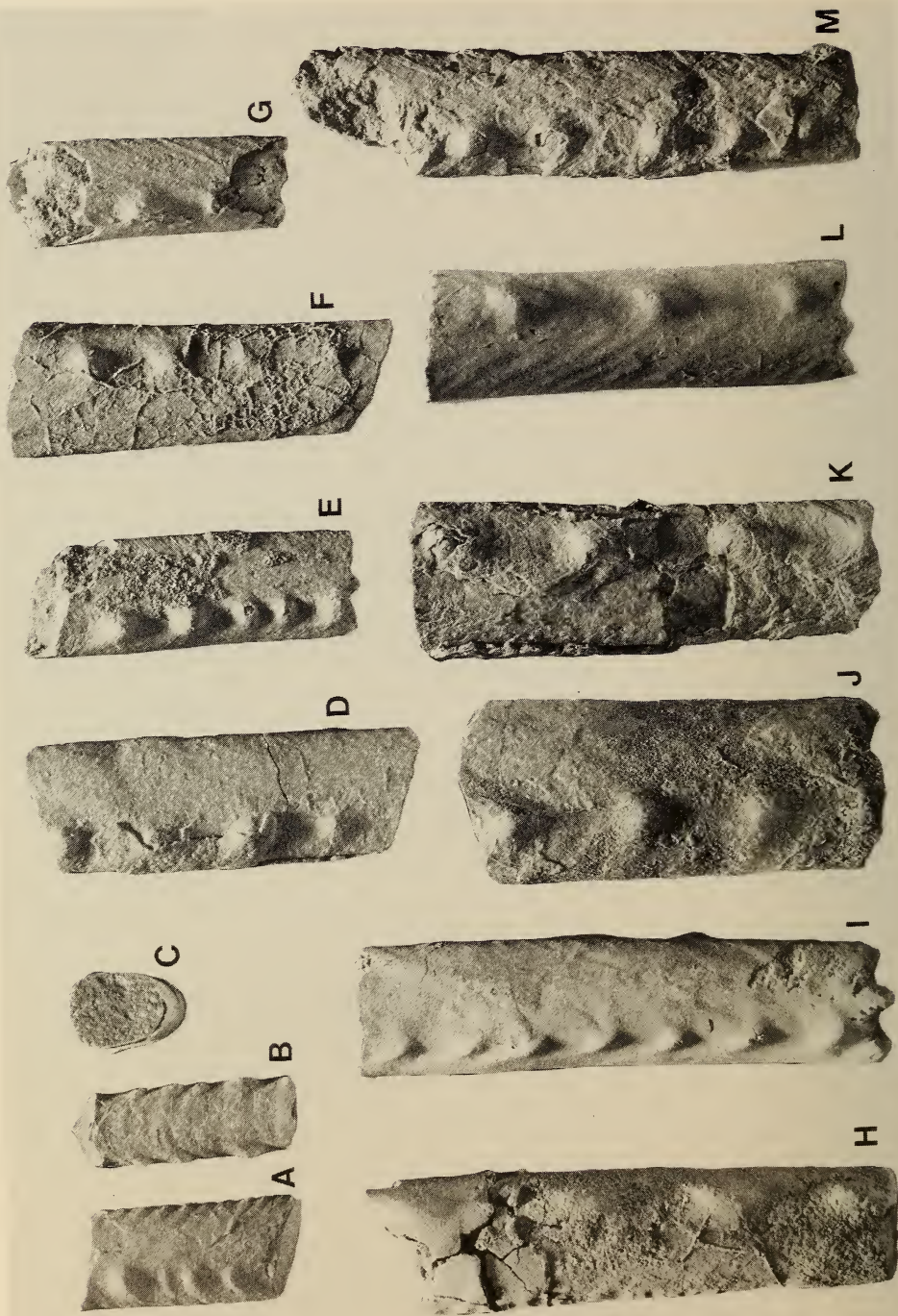


Fig. 33

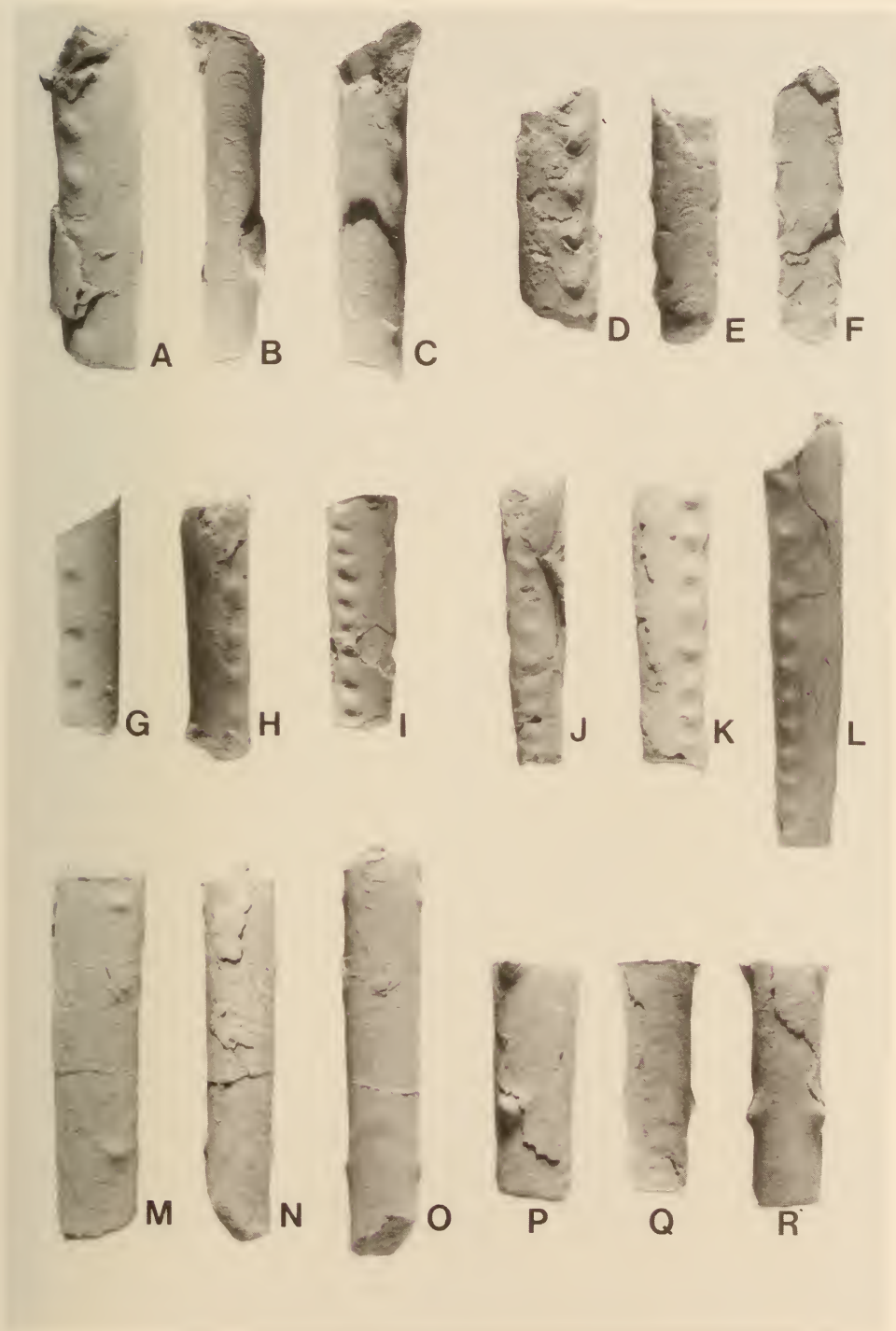


Fig. 34

localities. These morphological types are merely convenient reference points on which to base the descriptions of this material and have no taxonomic status whatsoever. Some have, in the past, been given varietal or specific names, and we try as far as possible to identify our morphotypes with these names. Their stratigraphic and phylogenetic relationships are discussed below.

Form 1 (= *Baculites* sp. aff. *B. capensis* Spath, 1921: 258). Predominantly smooth to feebly ornamented forms. These have the whorl section of typical *B. capensis*, but lack lateral ornament, e.g. NMB D1052/1 (Fig. 32A-C). In some, e.g. SAM-5467 (Fig. 48J), ornament consists of ventral corrugations only (= *Baculites* sp. cf. *sulcatus* of Spath 1921: 260). In others, e.g. SAM-PCZ8760 (Fig. 42I), NMB D1124 (Fig. 42J) and SAM-PCZ8027 (Fig. 42K-M), feeble lateral ornament may occur, as far as can be seen, on the body chamber only. Specimens reach maturity at very different sizes, e.g. SAM-5484c at Wh = 10 mm and PCZ7210 at Wh = 20 mm.

Form 2 (= *Baculites* cf. *brevicosta* Spath, 1921: 260, pl. 24 (fig. 5, 5a)); (= *B. schencki* Matsumoto, 1959: 113, pl. 32 (figs 1a-c, 2a-c, 3a-b, 4a-b, 5a-c, 6a-c), text-figs 12a-b, 13a-c, 14a-b, 15-21, 22a-b, 23a-c, 24-25). Small forms with closely spaced, crescentic tubercles situated near the dorsolateral edge of the flanks and ovoid whorl section (Fig. 34I-L, 36M-N, 42E). The tubercles may be narrow and pinched, or broad and low. Dorsally and ventrally the tubercles fade into fine striae. Whorl section generally ovoid.

Form 3 (= *Baculites* cf. *asperoanceps* Spath, 1921: 259, pl. 24 (fig. 4, 4a)). Small forms with closely spaced, generally conical to low, rounded tubercles situated near the dorsolateral edge of the flanks, e.g. SAM-PCZ8691 (Fig. 35A) and SAM-PCZ8699 (Fig. 35E). Forms with more widely spaced tubercles correspond to *B. boulei* Collignon (1931: 35, pl. 5 (fig. 2), pl. 9 (fig. 14)). A weak longitudinal groove may be visible at mid-flank. e.g. SAM-5480 (Fig. 34D-F), SAM-PCZ8675 (Fig. 35F) and PCZ8674b.

Form 4 (= '*incurvatus*'). Generally large forms with prominent conical to rounded tubercles, situated near the dorsal third of the flanks, e.g. SAM-PCZ9974 (Fig. 42A-D), SAS Z1795a-f (Fig. 44A-F) and SAS Z632a-c (Fig. 45A-E, I-J).

Fig. 35 (see facing page). *Baculites capensis* Woods, 1906. A. SAM-PCZ8691. B. SAM-PCZ8692. C. SAM-PCZ8749. D. SAM-PCZ8682. E. SAM-PCZ8699. F. SAM-PCZ8675. All from locality 83, Zululand, St Lucia Formation, Coniacian IV. G. SAM-PCZ8725. H. SAM-PCZ8720. J-K. SAM-PCZ8715. L. SAM-PCZ8711. M. SAM-PCZ8713. N-P. SAM-PCZ8717. Q. SAM-PCZ8762. R. SAM-PCZ8747. All from locality 85, Zululand, St Lucia Formation, Santonian I. All $\times 1$.

Fig. 36 (see overleaf). *Baculites capensis* Woods, 1906. A-C. SAM-PCZ12002. D-F. SAM-PCZ12003. G-I. SAM-PCZ12004. J-L. SAM-PCZ12005. O. SAS A1493b. All from locality 22, Zululand, St Lucia Formation, Coniacian IV. M. SAM-PCZ12006. N. SAM- 16026, both from Mkweyane ('Umkwelane Hill'), probably locality 10, Zululand. All $\times 1$.

Fig. 37 (see overleaf). *Baculites capensis* Woods, 1906. A-B. SAM-PCZ8674, concretion to show co-occurrence of smooth and weakly nodose (*boulei*) forms of *B. capensis*. From locality 83, Zululand, St Lucia Formation, Coniacian IV. Both $\times 1$.

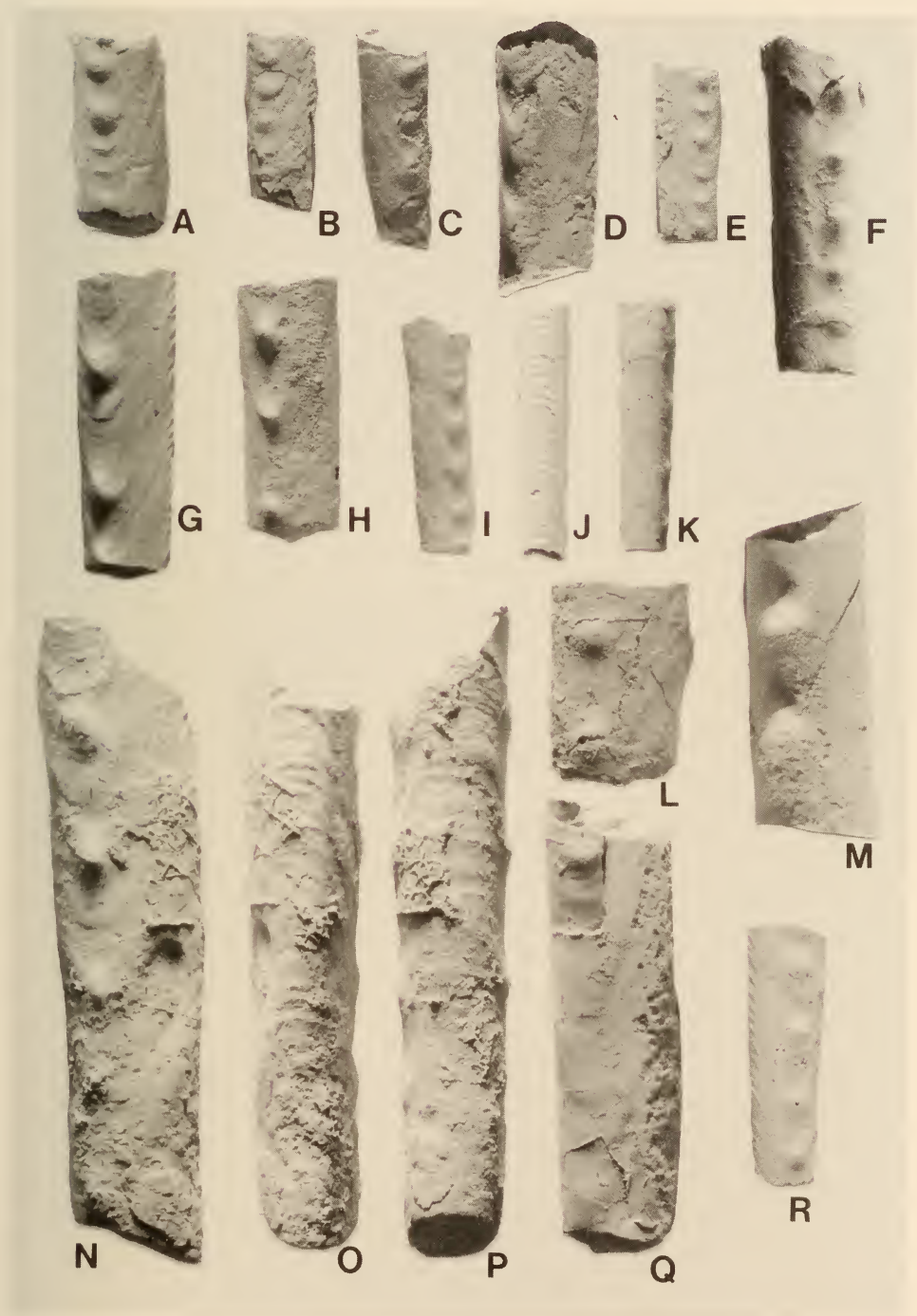


Fig. 35



Fig. 36

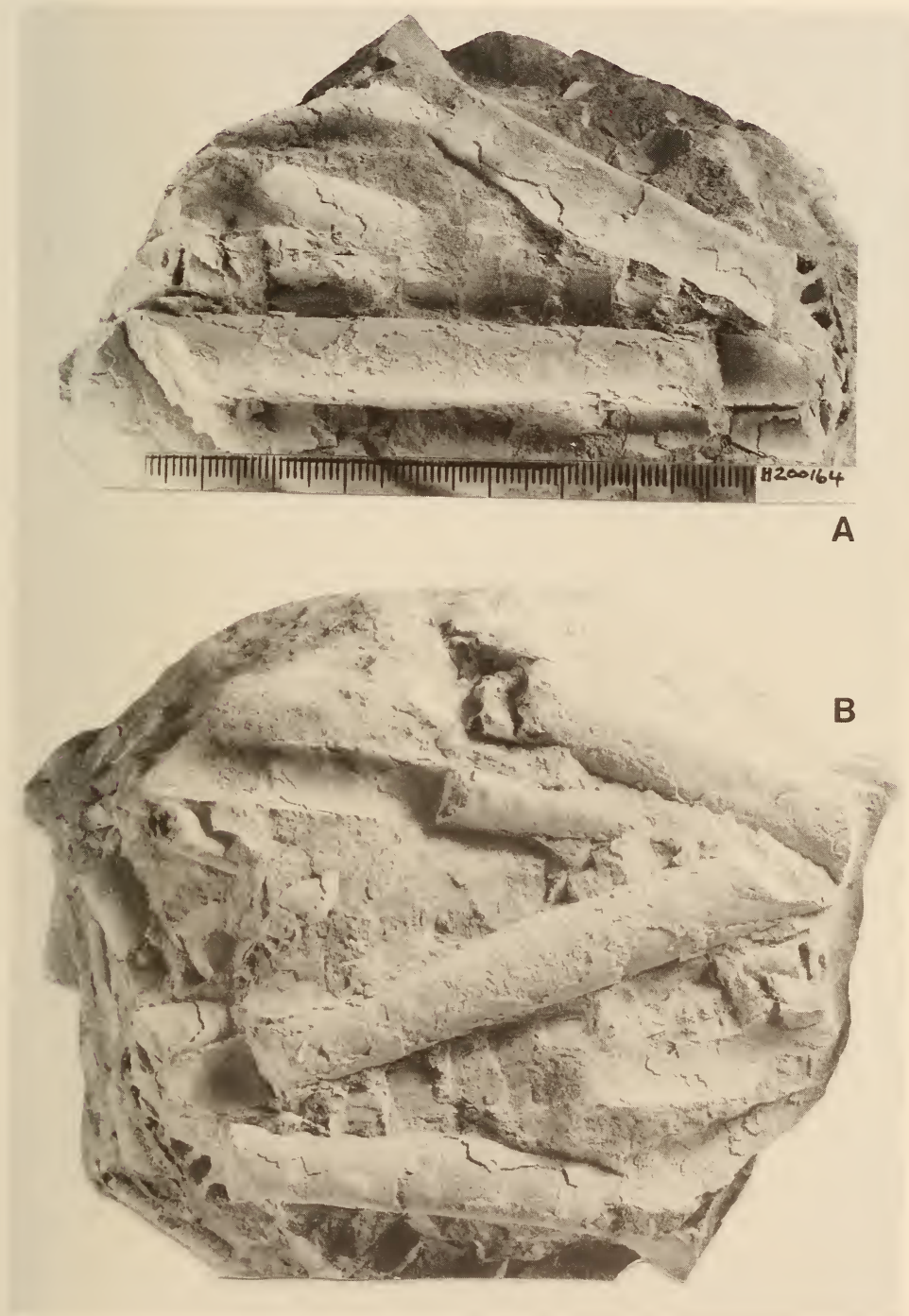


Fig. 37

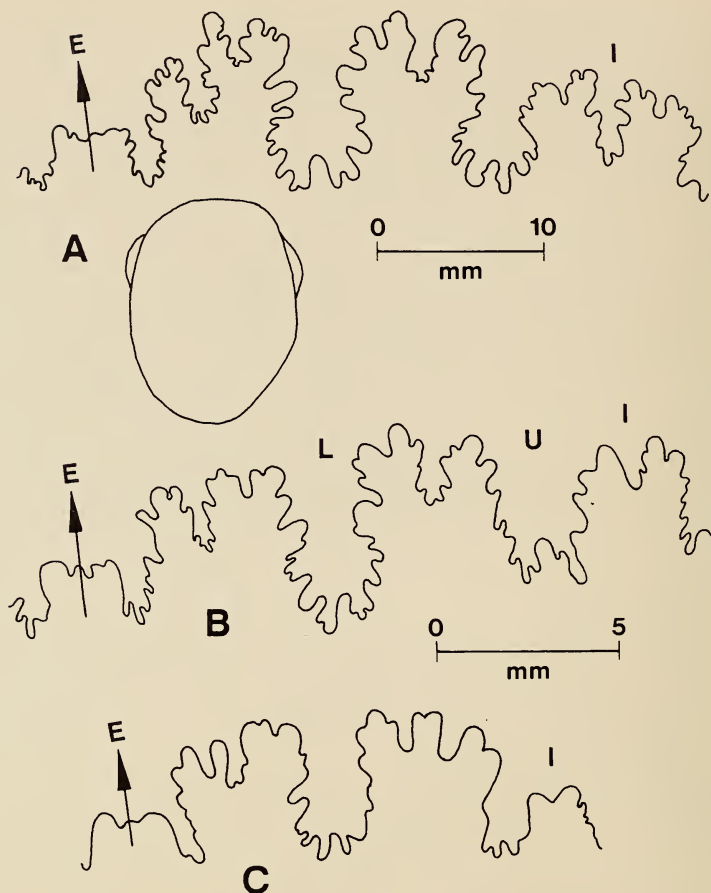


Fig. 38. *Baculites capensis* Woods, 1906. Suture lines and whorl section. A. SAS H13/6. B. SAS A335. C. SAM-1670b. Venter in whorl section pointing downward. Scale bar for size.

Form 5 (= var. *tenuetuberculata* Collignon, 1966: 6, pl. 457 (figs 1863-4). Generally large forms with weak conical to rounded tubercles, e.g. SAM-PCZ12002 (Fig. 36A-C). These are probably only large forms (macroconchs) of form 3.

Form 6. Generally large forms with prominent conical to crescentic, or transversely elongated tubercles, situated near dorsal third of flanks, e.g. NMB D1052a (Fig. 43A-C), NMB D1052c (Fig. 43F-H), SAS Z1795a (Fig. 46A-C) and SAS A353 (Fig. 47A-B).

Form 7 (= *capensis* typical form). Generally large forms with rounded to longitudinally elongated tubercles near the dorsal third of the flanks. Longitudinal depression often present near midflank; whorl section varies from sub-trigonal to distinctly elliptical, e.g. SAM-4823 (Fig. 27D-H) and SAM-4824 (Fig. 28B-E). In some, e.g. SAS Z632a (Fig. 45A-C), the transition from

conical ('*incurvatus*') to longitudinally elongated (*capensis*) tubercles can be observed on the same specimen.

Form 8 (= *B. capensis* in Collignon 1966: 6, pl. 457 (fig. 1862)). Tubercles extremely elongated longitudinally, assuming crescentic outline in dorsal view, e.g. NMB D1028/3 (Fig. 50A-C).

Form 9 (= var. *umsinenensis* Venzo, 1936: 116 [58], pl. 10 [6] (figs 11-12)). Tubercles elongated obliquely, some with shallow, longitudinal depression at mid-flank. Tubercles closely or widely spaced, generally situated high on the flank or near the dorsolateral edge, e.g. SAM-PCZ12016 (Fig. 50G-H), SAM-PCZ12017 (Fig. 50M), NMB D1028/12 (Fig. 50N) and SAS A361 (Fig. 33I, 49C-E). Some specimens with very large tubercles, e.g. NMB D1028/3 (Fig. 50A-C), are transitional between forms 8 and 9.

Form 10 (= *B. malagasyensis* Collignon, 1966: 7, pl. 457 (fig. 1865)). Tubercles are of the *capensis* or *incurvatus* type, but irregularly spaced or doubled.

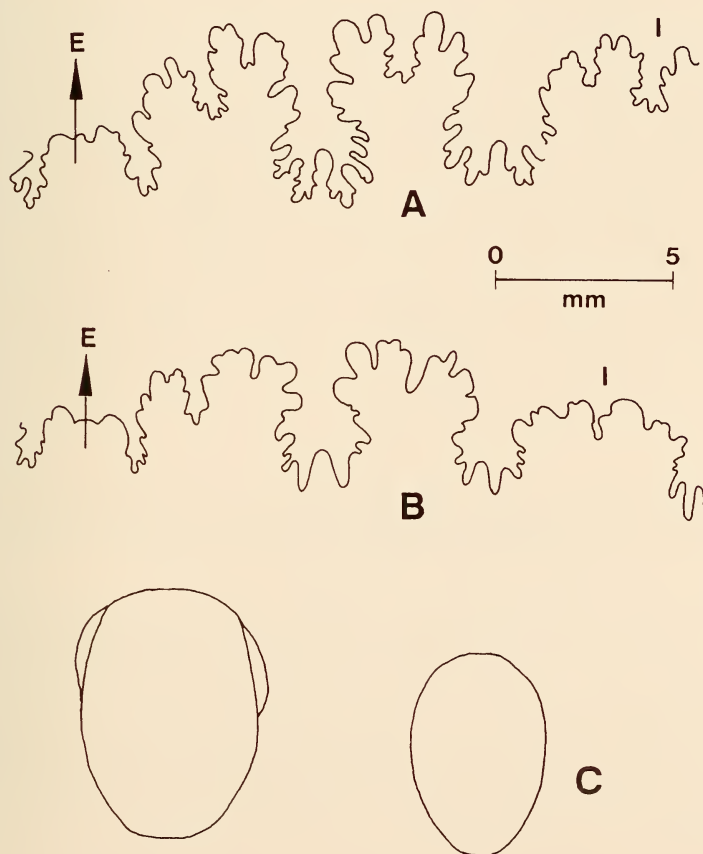


Fig. 39. *Baculites capensis* Woods, 1906. Suture lines and whorl sections. A. SAM-PCZ12007. B. SAM-PCZ12006. C. SAM-PCZ12008. Venter in whorl sections pointing downward. Scale bar for size.

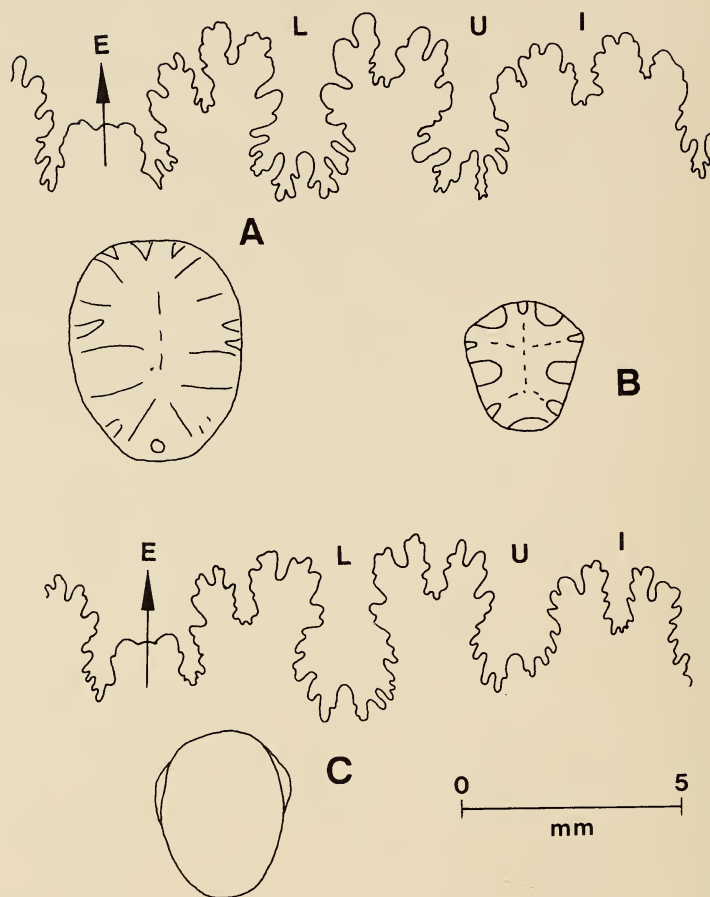


Fig. 40. *Baculites capensis* Woods, 1906. Suture lines and whorl sections. A. SASA2101. B. SAM-PCZ8039. C. SAM-PCZ12009. Venter in whorl sections pointing downward. Scale bar for size.

Form 11. (= ?*B. sparsinodosus* Collignon, 1969: 23, pl. 521 (figs 2052–2054)). Rare, ?Lower Campanian forms with large, rounded, distantly spaced tubercles, e.g. SAM-PCZ8022 (Fig. 54A), SAM-PCZ9971 (Fig. 54B) and SAM-PCZ9972 (Fig. 54C–E).

?Form 12. Rare Santonian specimens with very widely spaced tubercles, e.g. SAM-PCZ8387 (Fig. 34M–O) and SAM-PCZ8349 (Fig. 34P–R). We are not quite sure if these are true *B. capensis* or merely rare, tuberculate *B. bailyi*; faunal association suggests the latter.

Apertures and dimorphism

The aperture, or part thereof, is preserved in numerous (about 35) specimens (Figs 51A–N, 52A–D). It is simple, consisting of a short, rounded dorsal

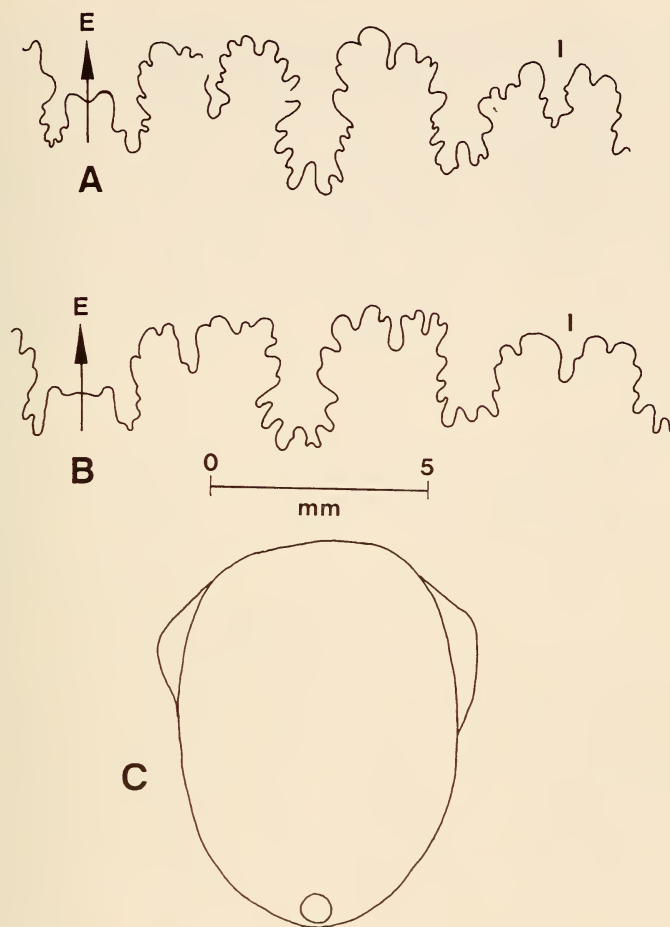


Fig. 41. *Baculites capensis* Woods, 1906. Suture lines and whorl section. A. SAM-PCZ9974. B-C. NMB D1028g. Venter in whorl section pointing downward. Scale bar for size.

rostrum, a prominent lateral sinus and a long, ventral rostrum. The dorsal rostrum may curve slightly outwards, i.e. away from the longitudinal axis of the shell, whereas the ventral rostrum may curve inwards.

The diameter at which apertures are formed and maturity presumably sets in, is quite variable (Fig. 53). The smallest whorl height at which indications of an aperture are present, is 9 mm, whereas some shells reach maximum whorl heights of 31 mm on the body chamber without having formed an aperture. Even though specimens at the smaller and larger ends of the distribution range may be distinguished as micro- and macroconchs respectively, there is no distinct break in size between them. An alternative interpretation is that this indicates a variable range of maturation size.

Most body chambers are perfectly straight, but some (e.g. NMB D1052c) (Fig. 43F-H) are slightly curved.

Suture lines

Details of the sutures are shown in Figures 38A–C, 39A–B, 40A, C, and 41A–B. The suture is very simple with open saddles and lobes.

Discussion

According to our interpretation, *B. capensis* is a predominantly nodose baculitid, which first appears in the second or third division of the Coniacian of Zululand, and persists to the second division of the Santonian in Pondoland and possibly to the first division of the Campanian in Zululand.

From the descriptions above, and the figures, it can be seen that the presence and shape of the lateral tubercles is extremely variable. This variation was already noticed by Spath (1921) in material from Mkweyane (Umkwelane Hill) collected by A. L. du Toit. Even though he referred several of the morphotypes present to extant species in open nomenclature, e.g. *Baculites* sp. aff. *capensis*, *Baculites* cf. *aspero-anceps*, *Baculites* cf. *brevicosta* and *Baculites* sp. cf. *sulcatus*, he admitted that all of these forms were probably only varieties of *B. capensis*. Our material not only confirms, but further illustrates the wide variety of ornament in *B. capensis*.

The ornament of the different morphotypes suggests that *B. capensis* could be derived from smooth *B. yokoyamai* through strengthening of groups or sheaves of striae near the dorsolateral parts of the flanks, thus forming weak, crescentic ('*brevicosta-schencki*') tubercles, as in form 2. Strengthening of these crescentic nodes could lead to form 3 type of ornament, and further strengthening and wider spacing to type 4. Longitudinal elongation of these tubercles could lead to typical *B. capensis*-type of ornament. Oblique arrangement of typical *B. capensis* tubercles could lead to form 9 '*umsinenensis*'-type of ornament and ultimately to *B. menabensis*–*B. tanakae* to be discussed below. Alternatively, '*umsinenensis*'-type of ornament could be transitional between form 2 *brevicosta* and form 7 (typical *capensis*). The suggested evolution of *capensis*-type ornament from smooth *B. yokoyamai* is outlined in Figure 55.

Unfortunately, the answer is not that simple. This transition does not involve a simple change from a population of smooth baculitids through crescentic to conically nodose to longitudinally elongated tuberculate baculitids. Instead, the transition seems to involve subtle shifts in proportions of the population. The appearance and disappearance of distinct morphological features are not strictly synchronous. Thus, the first appearance of nodose baculitids does not mean that all smooth forms disappear (see e.g. Figs 29, 37)—instead, smooth forms continue to exist at least until the first appearance of typical *capensis* forms. Typical *capensis* forms first appear together with weakly nodose forms, long before

Fig. 42 (see facing page). *Baculites capensis* Woods, 1906. A–D. SAM-PCZ9972. E. NMBD1124/4. F–G. NMBD1028. H. SAM-PCZ12010. I. SAM-PCZ8760. J. NMBD1124. K–M. SAM-PCZ8027, all from locality 72, Zululand, St Lucia Formation, Coniacian III. All $\times 1$.

Fig. 43 (see overleaf). *Baculites capensis* Woods, 1906. Body chambers. A–C. NMBD1052a. D–E. NMBD1052d. F–H. NMBD1052c (note slight curvature). All from locality 73, Zululand, St Lucia Formation, Coniacian IV–V. All $\times 1$.

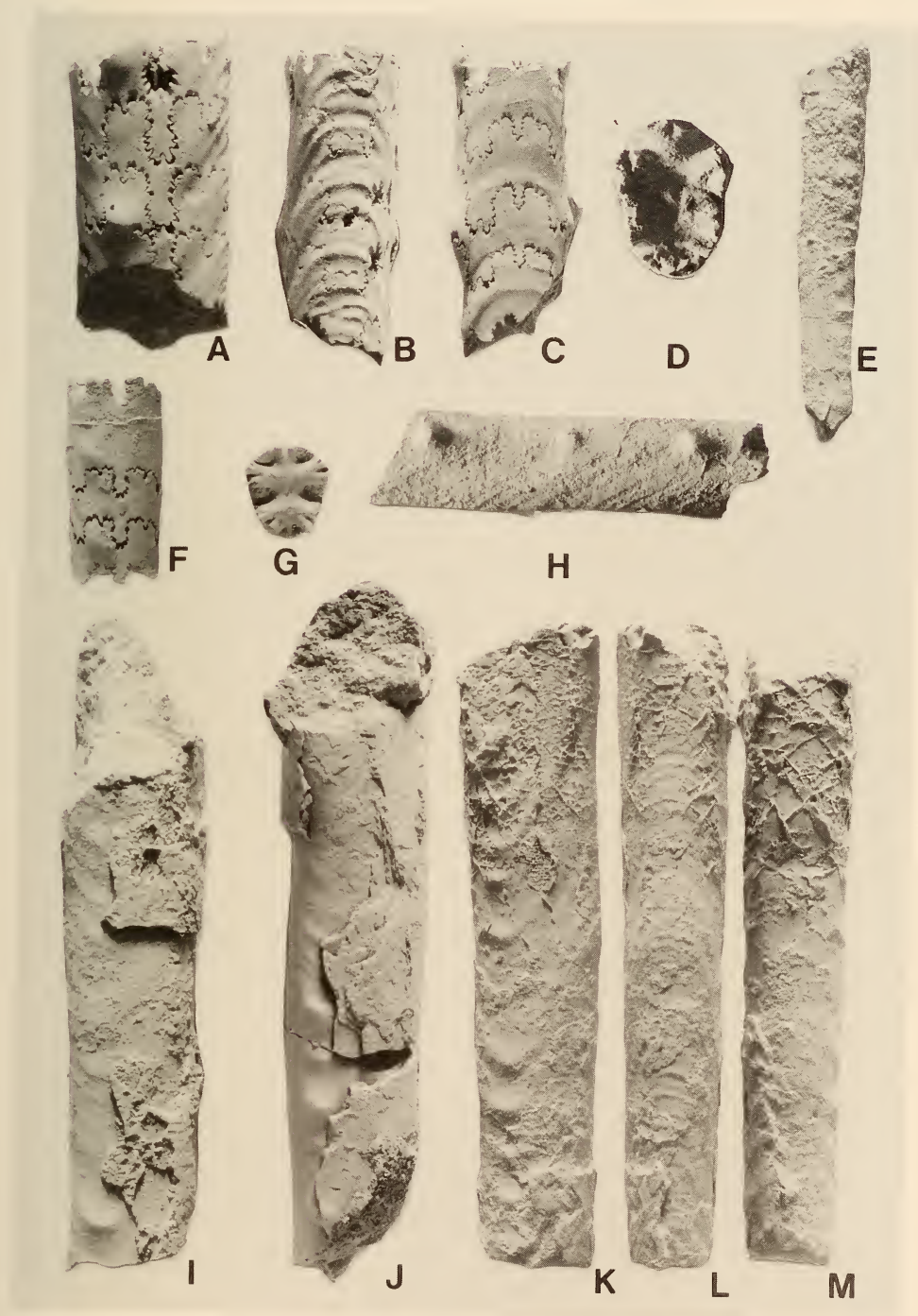


Fig. 42

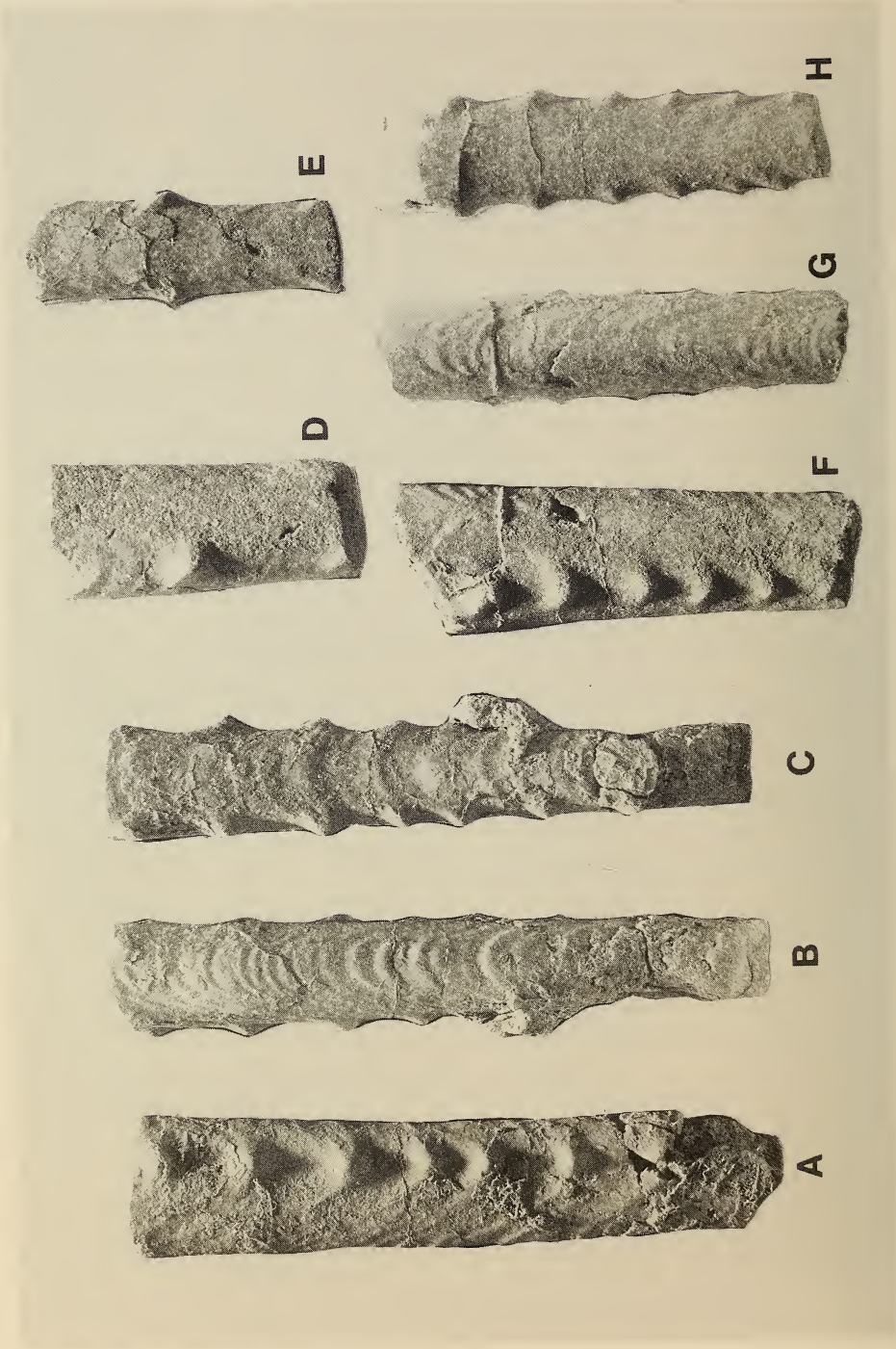


Fig. 43

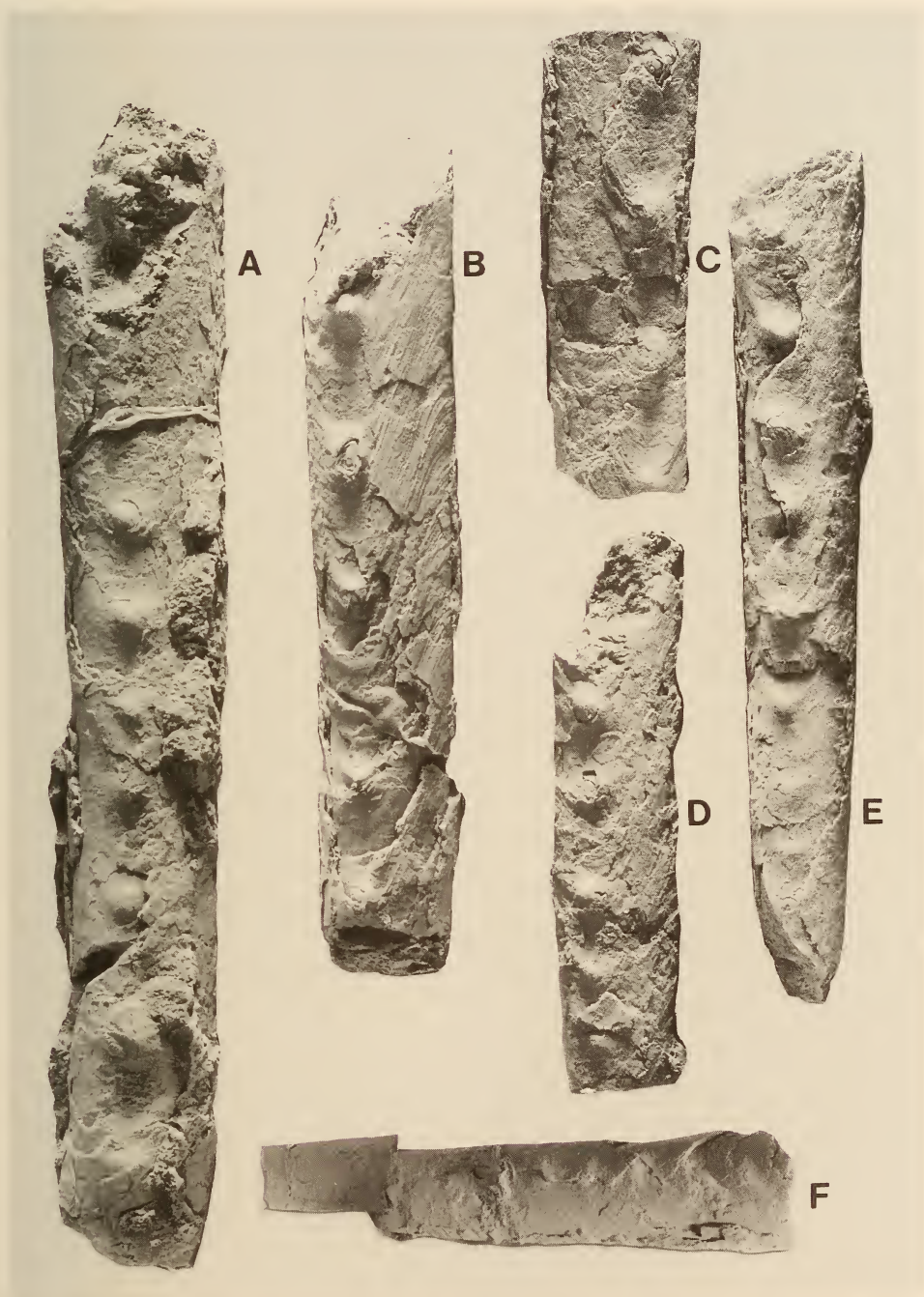


Fig. 44. *Baculites capensis* Woods, 1906. A. SAS Z1795a. B. SAS Z1795c. C. SAS Z1795f. D. SAS Z1795. E. SAS Z1795d. F. SAS Z1795l. All from locality 85, Zululand, St Lucia Formation, Santonian I. All $\times 1$.

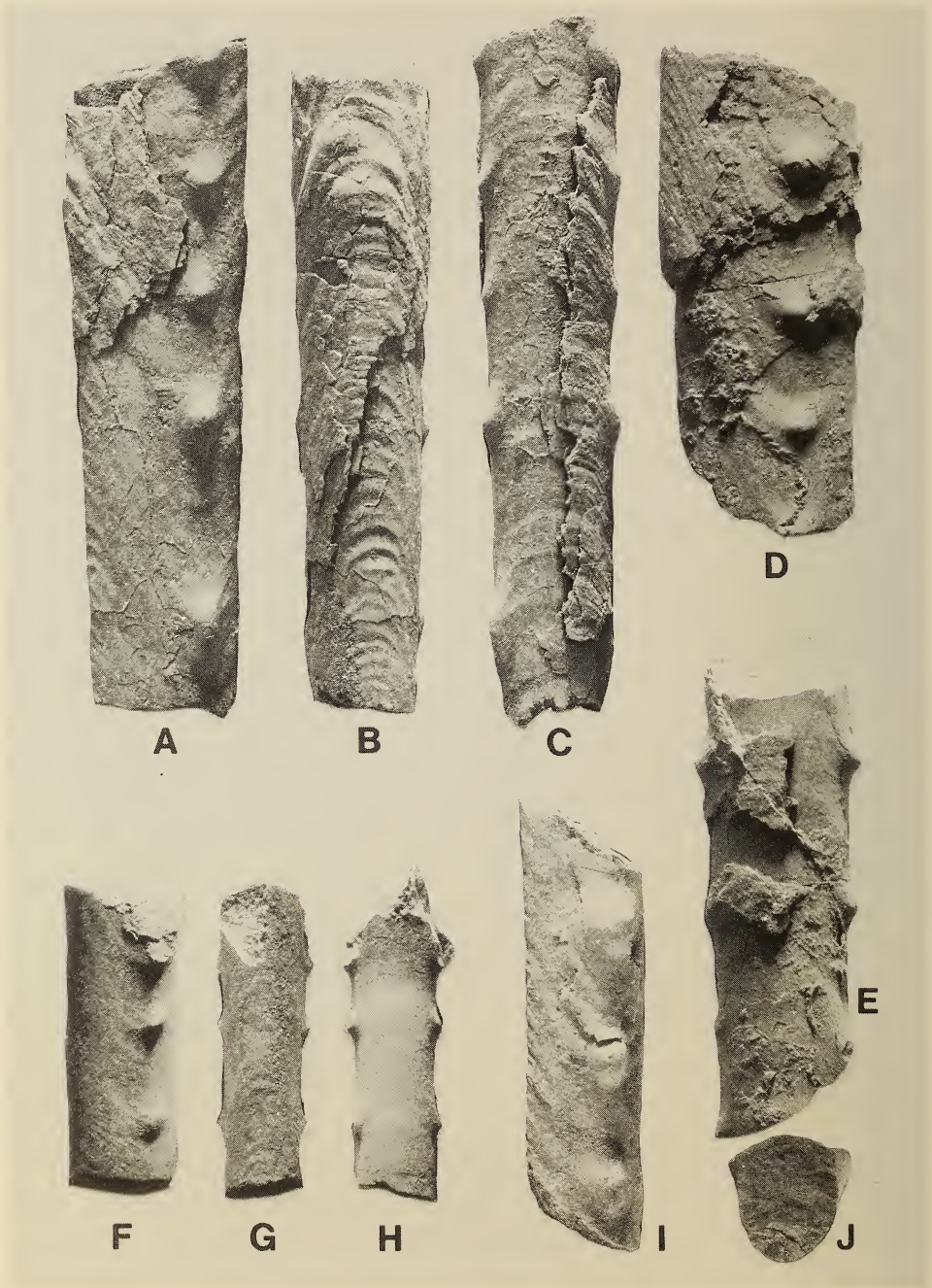


Fig. 45. *Baculites capensis* Woods, 1906. A-C. SAS Z632a. D-E. SAS Z632b. F-H. SAS Z632e. I-J. SAS Z632c. All presumably from locality 91, Zululand, St Lucia Formation, Coniacian IV or V. All $\times 1$.



Fig. 46. *Baculites capensis* Woods, 1906. A-C. SAS Z1795a. Macroconch with part of the aperture preserved. From locality 85, Zululand, St Lucia Formation, Santonian I. All $\times 1$.

capensis-type of ornament reaches its peak. Also, many of these different morphological types, even though stratigraphically contemporaneous, seem to be concentrated at different localities (see e.g. Fig. 35 (Coniacian IV), Fig. 43 (Coniacian IV–V), Fig. 44 (Coniacian IV–V), Fig. 45A–E, I–J (Coniacian IV or V), Figs 49C–E, 50A–C, N (Coniacian IV–V), etc.). Thus it is very common for baculitids from a single locality all to be the same, but different from those from another locality at more or less the same stratigraphic level.

Forms 1–3, i.e. smooth or with small crescentic or weakly conical tubercles situated near the dorsolateral edge of the flanks, are most common amongst the first representatives of the species in the second and third divisions of the Coniacian, but typical *capensis* forms with elongated tubercles also occur. This includes most of the baculitids described from Umkwelane Hill (Mkweyane) by Spath (1921). A similar early *capensis* baculitid assemblage occurs at locality 15. In the fourth division of the Coniacian tuberculate forms of group 3 (*boulei*) dominate, but smooth forms still persist, often in the same nodule (Fig. 37); in addition, typical forms of *capensis*, including forms 4–9 occur.

In the later part of the Coniacian and in the first two divisions of the Santonian, forms 4–9 dominate, but weakly ornamented forms still occur. Normally we find that, at a given locality, the baculitids will not occur as a random mixture of the different morphological types, but that one form will be dominant (see e.g. specimens Z1795a, c–f (Figs 44A–F), Z632a–b, e (Fig. 45A–J) and D1052a, c–d (Fig. 43A–H), all from more or less the same stratigraphic level but different localities). Based purely on morphological criteria, each of these morphotypes could be given a different name, but from a stratigraphic point of view, this would be illogical.

One morphotype that seems to be most common at, but not exclusively restricted to, the outcrops along the Mzinene River at localities 71 and 73, is form 9 (*umsinenensis*). Typical forms with distinct obliquely elongated tubercles are best known, and first recorded by Crick (1907: 240) and later by Venzo (1936: 116 [58], pl. 10 [6] (figs 11–12)) from this locality, but similar specimens are also known from localities 22, 91, and 83.

Specimens with extremely elongated tubercles (form 8) are rare (Figs 33H, 50A). Forms with extremely distant tuberculation (form 11) are also rare and have thus far only been found in rubble from excavations at locality 6, which yielded a mixed Santonian II–III and/or Campanian I fauna. We think that these baculitids are from the Campanian section of the excavations, but are not sure. The ornament is comparable to material from the Lower Campanian of Madagascar described by Collignon (1969) as *B. sparsinodosus*.

Form 12 is extremely rare and is mostly found in association with abundant Santonian specimens of *B. bailyi*. Because of this, we suspect that these may rather be atypical, nodose *B. bailyi* than *B. capensis*, but again we cannot be completely sure.

Form 11 (*malagasyensis*) is merely a *capensis* with irregular spacing of the tubercles.

Fig. 47. *Baculites capensis* Woods, 1906. Body chamber specimens. A–B. SAS A353. C. SAM-PCZ8011. D–F. SAM-PCZ12011. All from locality 73, Zululand, St Lucia Formation, Coniacian IV or V. All $\times 1$.

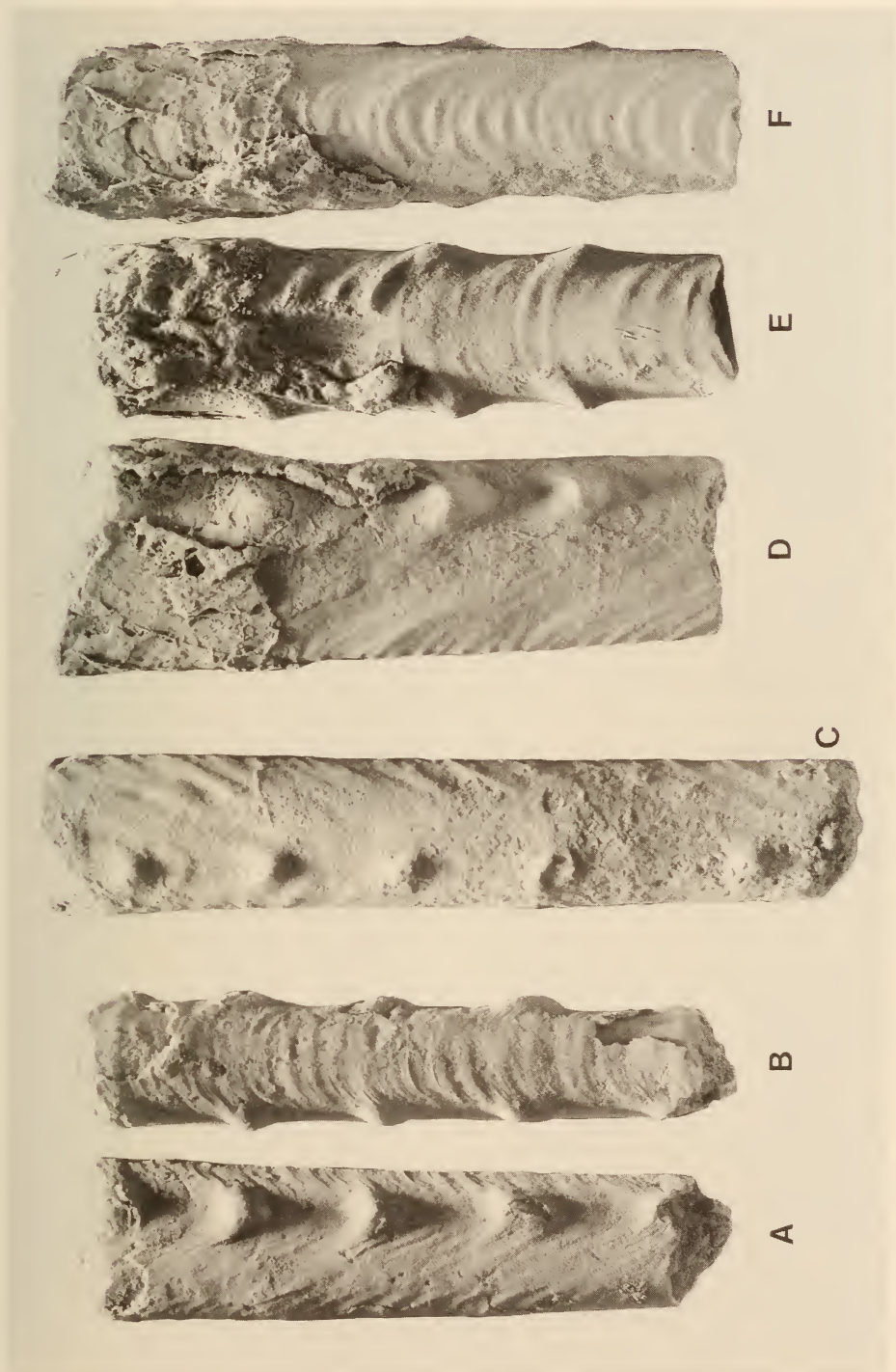


Fig. 47

Affinities and comparisons

Our interpretation of *B. capensis* is very broad, and consequently it is very difficult or in cases impossible to separate it satisfactorily from similar, contemporary species known only from a few individuals and where the range of variation is unknown.

The first problem is separating *B. capensis* from *B. bailyi*. It is easy to name the first nodose specimens *B. capensis*, but what should we call the smooth variants? We consider it expedient to regard these smooth specimens as variants of early *B. capensis*, albeit mainly by their co-occurrence with these nodose forms. Fortunately, these smooth forms of *B. capensis* are generally larger than *B. bailyi*, and have the whorl section of the former species, but separation of isolated specimens remains difficult. Also, in some of the early forms of *B. capensis*, e.g. SAM-PCZ8030 (Fig. 49J), tubercles only appear at a relatively late stage. The early, non-tuberculate parts of these shells are indistinguishable from *B. yokoyamai* or *B. bailyi*.

Contemporary, nodose baculitids appear to be separated into three distinct bio(?)geographic regions:

A. Indo-Pacific Region

- i. *Baculites boulei* Collignon (1931: 35, pl. 5 (fig. 2, 2a), pl. 9 (fig. 14)).
- ii. *Baculites schencki* Matsumoto (1959: 113, pl. 32 (figs 1-6), text-figs 12a-b, 13a-c, 14a-b, 15-21, 22a-b, 23a-c, 24-25).

B. Western Interior of North America

- i. *Baculites codyensis* Reeside (1927: 4, pl. 2 (figs 6-9)).

Fig. 48 (*see facing page*). *Baculites capensis* Woods, 1906. A. SAM-PCZ7198a from locality 73, Zululand, St Lucia Formation, Coniacian IV or V. B. SAM-PCZ12012 (H200/84), body chamber with part of aperture preserved. From locality 83, Zululand, St Lucia Formation, Coniacian IV. C. SAM-PCZ12013, body chamber showing transition from conical to elongate, *capensis* tuberculation. From locality 16, Zululand, St Lucia Formation, Coniacian ?III. D. SAM-PCZ12014 from locality 22, Zululand, St Lucia Formation, Coniacian IV. E. SAM-PCZ7210, body chamber with hardly perceptible tubercles from locality 72, Zululand, St Lucia Formation, Coniacian III. F-H. SAM-5443 from Mkweyane ('Umkwelane Hill'), Zululand. I. SAM-PCZ12015 from locality 89, Zululand, St Lucia Formation, Coniacian IV. J. SAM-5467, body chamber with no tuberculation; the original of Spath's (1921: 260) *Baculites* sp. cf. *sulcatus* from Mkweyane ('Umkwelane Hill'), Zululand. All $\times 1$.

Fig. 49 (*see overleaf*). *Baculites capensis* Woods, 1906. A-B. SAS A334. C-E. SAS A361—specimen with typical '*umsinenensis*' type of ornament. F-I. SAS A137—specimen showing shallow longitudinal groove under oblique lighting. All from locality 73, Zululand, St Lucia Formation, Coniacian IV-V. J. SAM-PCZ8030, microconch, showing transition from smooth to weakly tuberculate '*brevicosta*' type of ornament. From locality 15, Zululand, St Lucia Formation, Coniacian IV. All $\times 1$.

Fig. 50 (*see overleaf*). *Baculites capensis* Woods, 1906. A-C. NMBD1028/3. D-F. SAS A606. G-I. SAM-PCZ12016. J-L. SAS A335. M. SAM-PCZ12017. N. NMBD1028/12. A-C, G-I, M-N—all specimens with obliquely elongated tubercles of the '*umsinenensis*' form 9 type, but note the variation in strength; A-C is closest to form 8; D-F, with irregularly spaced, incipiently doubled tubercles, as in *B. malagasyensis*. All $\times 1$.

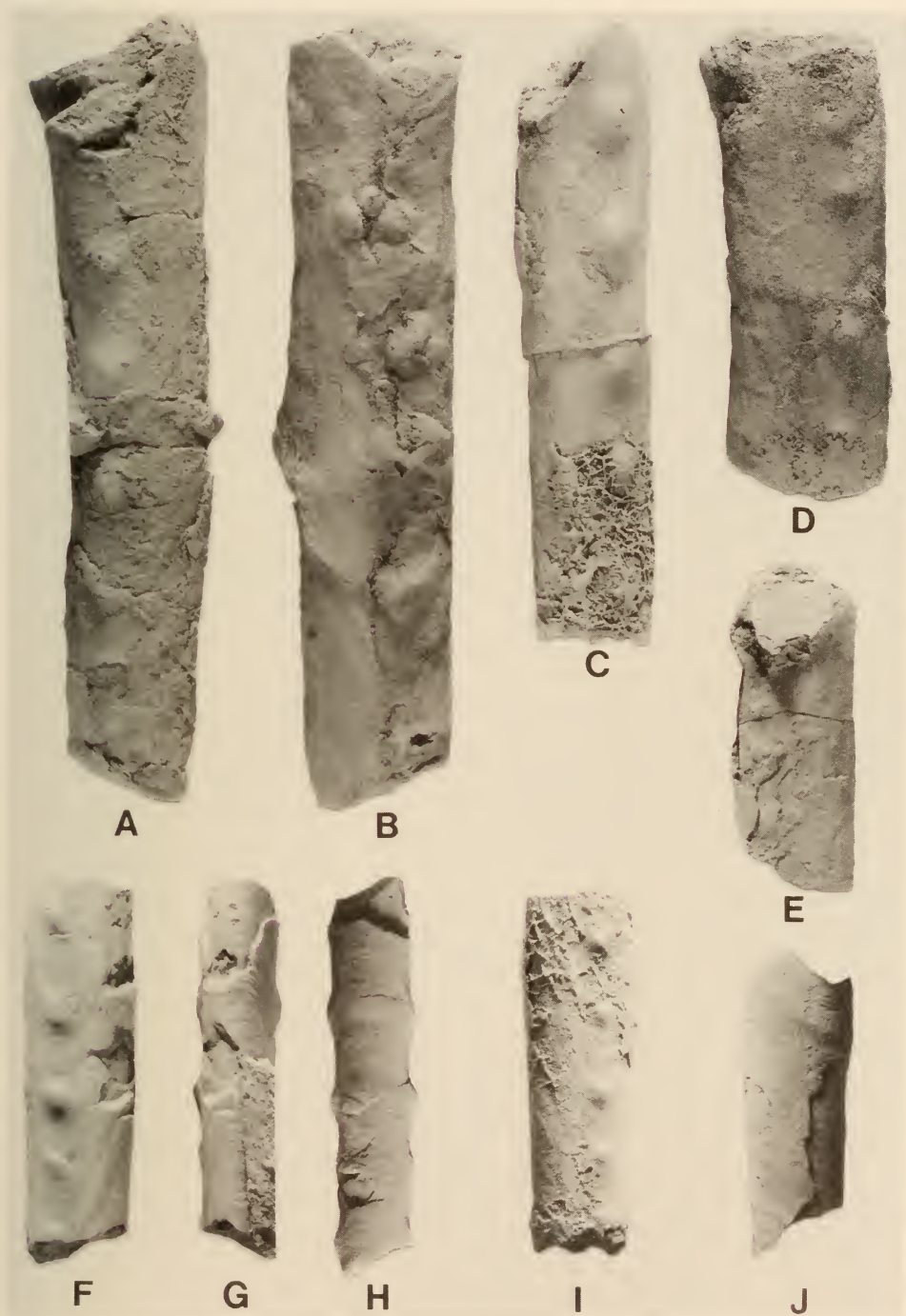


Fig. 48

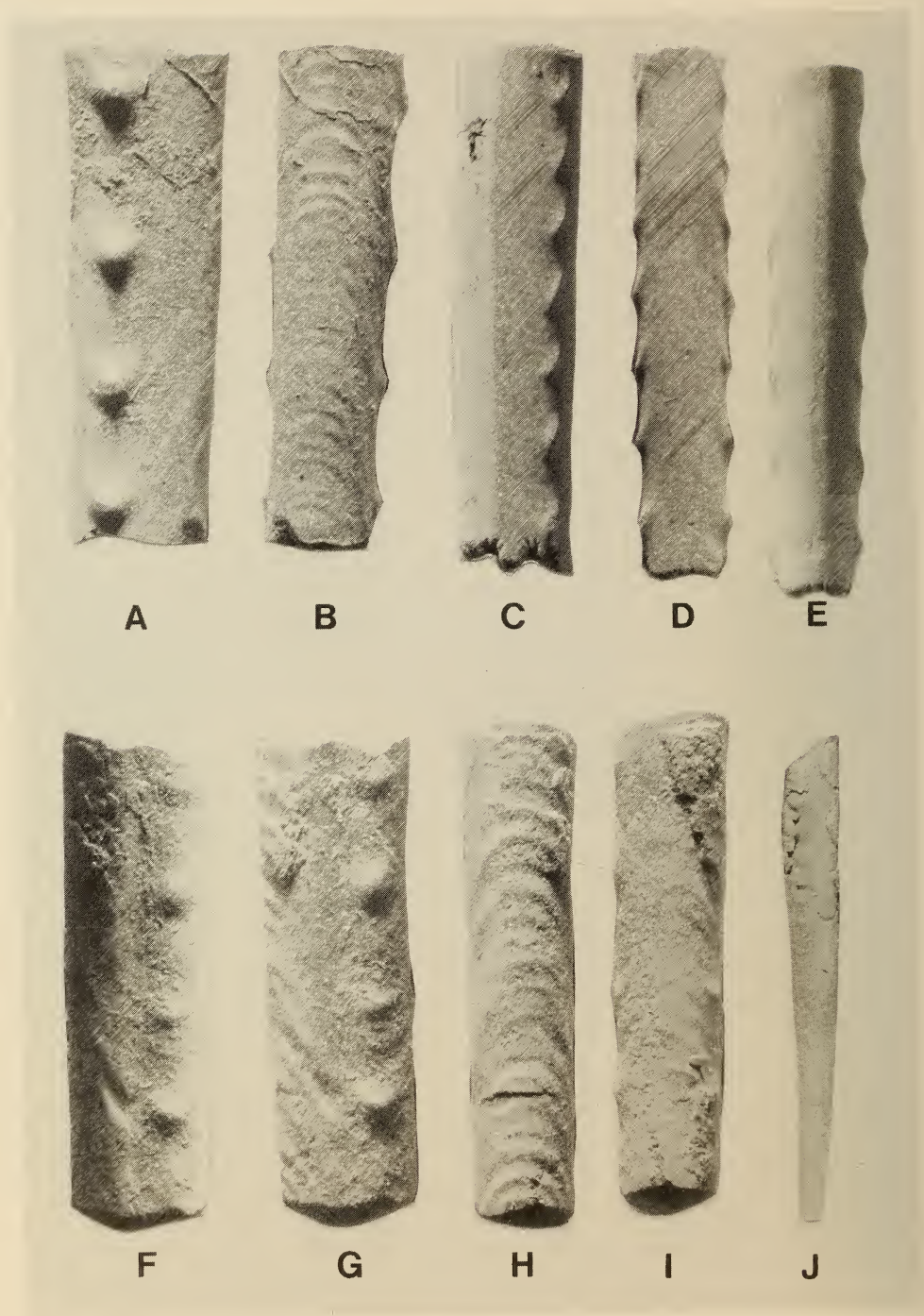


Fig. 49

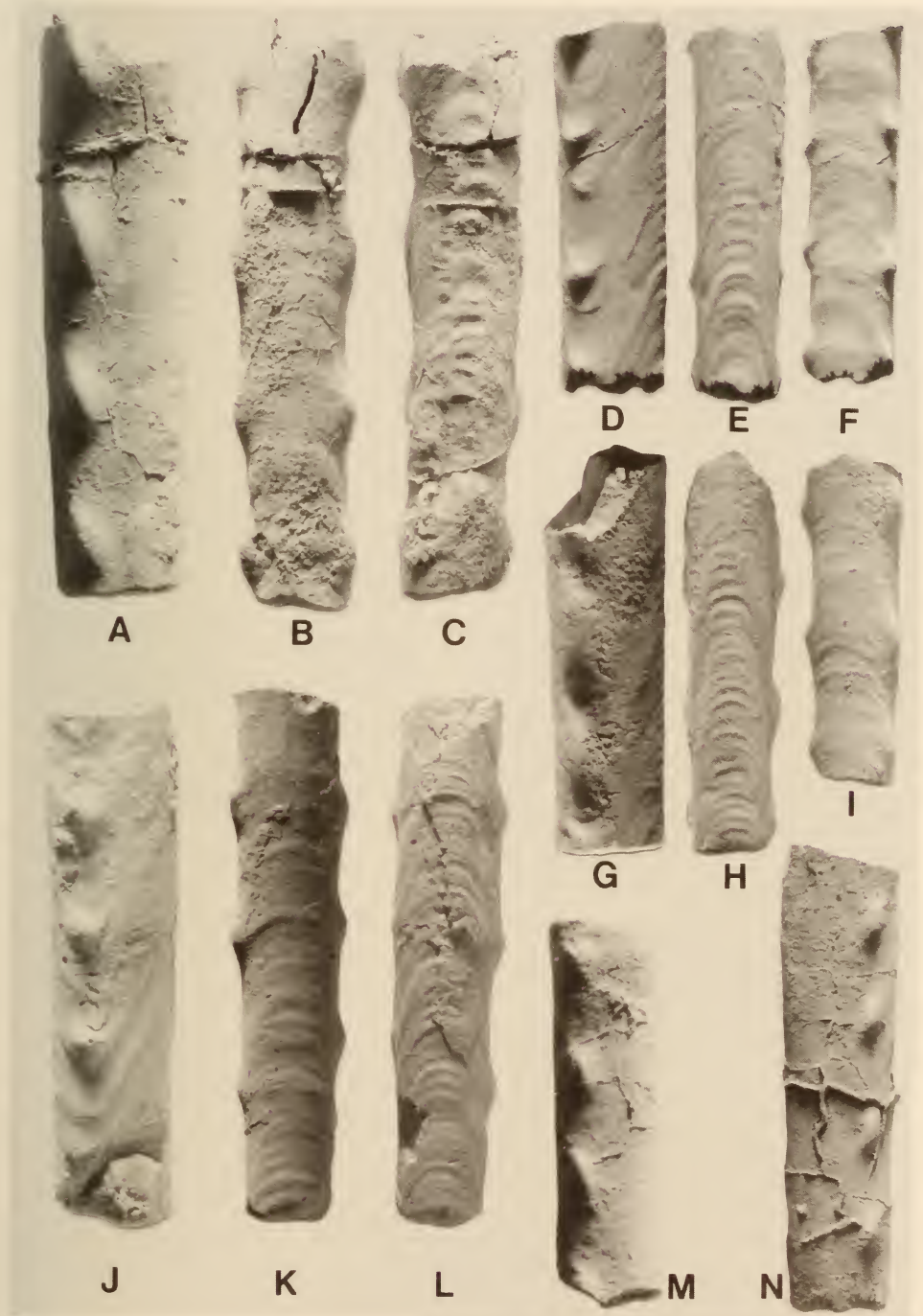


Fig. 50

C. European Tethyan and Boreal Region

- i. *Baculites incurvatus* Dujardin (1837: 232, pl. 17 (fig. 13)).
- ii. *Baculites brevicosta* Schlüter (1876: 141, pl. 39 (figs 9–10)).

A. Indo-Pacific. *Baculites boulei*—Collignon established this species based on nine syntypes. The lectotype, by subsequent designation of Matsumoto (1959: 118), is the specimen figured by Collignon (1931, pl. 5 (fig. 2, 2a)) (herein Fig. 12J–L) from Mahagaga, Madagascar.

Baculites boulei has been interpreted in various, contradictory ways, including by Collignon himself. As discussed above (p. 27), *B. boulei* was described from a ferruginous conglomerate north-north-east of Mahagaga. Five other 'species' of *Baculites* were found in association with *B. boulei*, one with arcuate lateral tubercles—, *Baculites* cf. *B. brevicosta* Schlüter (Collignon 1931: 34, pl. 5 (fig. 1, 1a), pl. 9 (fig. 13) (3 specimens), and four non-tuberculate 'species': *B. sulcatus* Baily (Collignon 1931: 36, pl. 5 (figs 3–5), pl. 9 (fig. 15)) (24 specimens), *B. besairiei* Collignon (1931: 37, pl. 5 (figs 6–9), pl. 9 (fig. 16)) (150 specimens), *B. roedereri* Collignon (1931: 38, pl. 5 (fig. 10, 10a), pl. 9 (fig. 17)) (1 specimen), and *B. latelobatus* Collignon (1931: 38, pl. 5 (figs 11–12), pl. 9 (fig. 18)) (3 specimens). The latter four smooth 'species' are all considered synonyms of *B. yokoyamai*, as stated above.

According to Collignon's (1931: 35) original diagnosis, *B. boulei* is ornamented every 7–8 mm by a large low tubercle, which is arched and concave, and elongated forward into a thin rib; between two successive tubercles, there are 4–5 intercalatory ribs, which are visible only in the siphonal region and in the immediate vicinity of the flanks. The species is similar to *B. capensis*, but, according to Collignon (1931: 36) differs by its whorl section being distinctly oval.

According to Collignon's description and, judging by the faunal association and age, it is clear that *B. boulei* is an early form of *B. capensis* as here interpreted, thus corresponding to form 3.

Collignon later recorded *B. boulei* (1938: 88, pl. 6 (figs 6–6b)), together with *Baculites incurvatus* (Collignon 1938: 88, pl. 6 (figs 4, 4a–5, 5a)) and *Baculites* cf. *B. aspero-anceps* (Collignon 1938: 89, pl. 6 (fig. 7–7b)) from unequivocal Campanian strata at Andimaka. This is clearly incorrect, as is Förster's (1975: 168, pl. 4 (figs 3, 9), text-fig. 37) record of *B. boulei* from the Lower Campanian of Mozambique. The suture figured by Förster as that of *B. boulei* is more complex than that of Collignon's original figure. *Baculites* cf. *B. asperoanceps* has a trigonal whorl section, and seems close to *B. nibelae* sp. nov. (see p. 162) from the Upper Campanian of Zululand or perhaps *B. incre-scens*. (True *B. asperoanceps* Lasswitz (1904: 16 (236), pl. 3 (15) (fig. 1a–b)) (lectotype figured herein Fig. 129) is a Campanian species and possibly a synonym of *B. obtusus*.)

Fig. 51 (see facing page). *Baculites capensis* Woods, 1906. Various specimens with parts of the aperture preserved. A–C. NMBD1028/4. F. NMBD1124. K–N. NMBD1024/10, all from locality 72, Zululand, St Lucia Formation, Coniacian II or III. D. SASZ632e from locality 91, Zululand, St Lucia Formation, Coniacian IV or V. G. SAM-1621b from an unrecorded locality. H–J. SAM-PCZ12018 from locality 83, Zululand, St Lucia Formation, Coniacian IV. All $\times 1$.

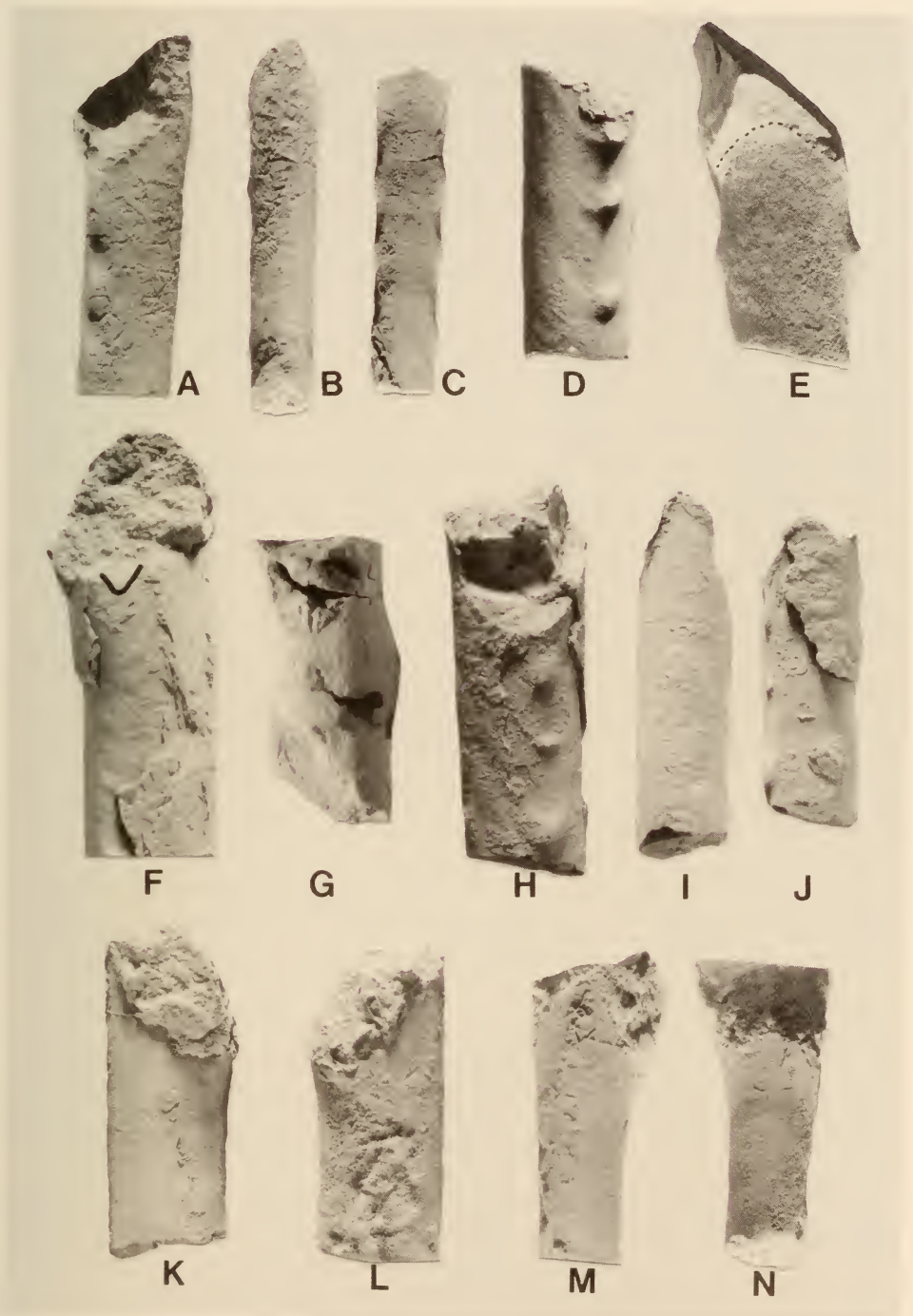


Fig. 51



Fig. 52. *Baculites capensis* Woods, 1906. Two specimens with preserved apertures at disparate sizes to illustrate dimorphism. A-C. Microconch. NMBD1075 from locality 73, Zululand, St Lucia Formation, Coniacian IV or V. D. Macroconch. SAS Z1795a from locality 85, Zululand, St Lucia Formation, Santonian I. Both $\times 1$.

Matsumoto (1959: 118, pl. 32 (fig. 7a-c), pl. 33 (figs 4a-c, 5a-b, 6a-d, 7a-b), text-figs 27a-b, 28-32) recorded *B. boulei* from California, the first record of the species outside Madagascar. Some of the Californian specimens were reported together with *B. schencki*, from 'Member V of the Redding area', which was dated as Coniacian. According to Haggart (1984) and Haggart & Ward (1989: 226), however, all the Californian occurrences of *B. boulei* are Santonian.

Haggart & Ward (1989: 226, fig. 3.7-3.10) recorded a single specimen of *Baculites* cf. *B. boulei* from the Santonian-Campanian of Vancouver Island. Ornament is of the *brevicosta* form 2 type of *B. capensis*, but this is mainly an early Coniacian form. As Haggart & Ward (1989: 226) suggested, the Vancouver specimen resembles *B. tanakae* and is probably a late form of *B. capensis* transitional to *B. tanakae*.

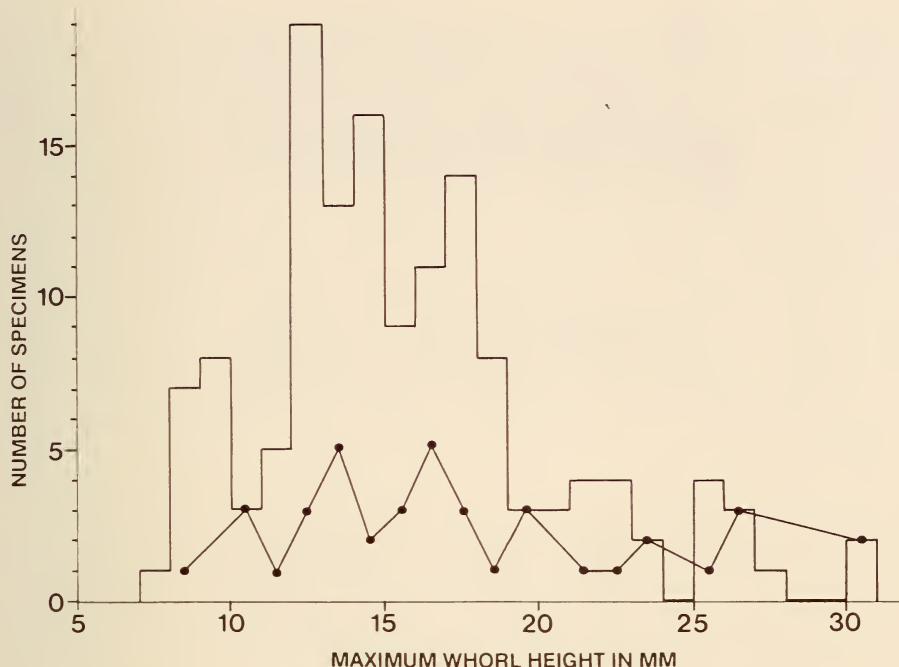


Fig. 53. *Baculites capensis* Woods, 1906. Histogram illustrating distribution of maximum whorl height. Solid circles represent specimens with the aperture preserved. Note the absence of a sharp break between apparent macro- and microconchs suggesting, perhaps, a uniform variable range of maturation sizes.

Matsumoto & Obata (1963: 43, pl. 13 (figs 3, 5), pl. 15 (fig. 6), text-figs 93, 152-155) subsequently described *B. boulei* from Hokkaido, where it is partly coeval with both *B. capensis* and *B. schencki*, i.e. Coniacian and Santonian (Matsumoto & Obata, text-fig. 216).

Kennedy (1986b: 112) regarded *B. boulei* as having a stouter whorl section than *B. capensis* and more closely spaced tubercles, which lie nearer to the dorsum than in the latter species.

Baculites schencki Matsumoto (1959: 113, pl. 32 (figs 1a-c, 2a-c, 3a-b, 4a-b, 5a-c, 6a-c), text-figs 12a-b, 13a-c, 14a-b, 15-21, 22a-b, 24-25) typically has an ovoid whorl section, and closely spaced, crescentic lateral nodes. It differs in typical forms from *B. boulei* by the weaker lateral ornament, and the narrower venter, but intermediate forms occur. This is very similar to, or identical with what we regard as form 2 of early *B. capensis*.

According to Matsumoto (1959: 120), the stratigraphic ranges of the two species overlap in California: *B. schencki* is more common in the lower part (of Member IV and V of the Redding area), whereas *B. boulei* is relatively common in the upper part.

In comparing *B. boulei* and *B. schencki* with *B. capensis*, Matsumoto (1959: 125) remarked that in California 'the three species, *B. schencki*, *B. boulei* and *B. capensis* are nearly contemporary, but their stratigraphic positions of the

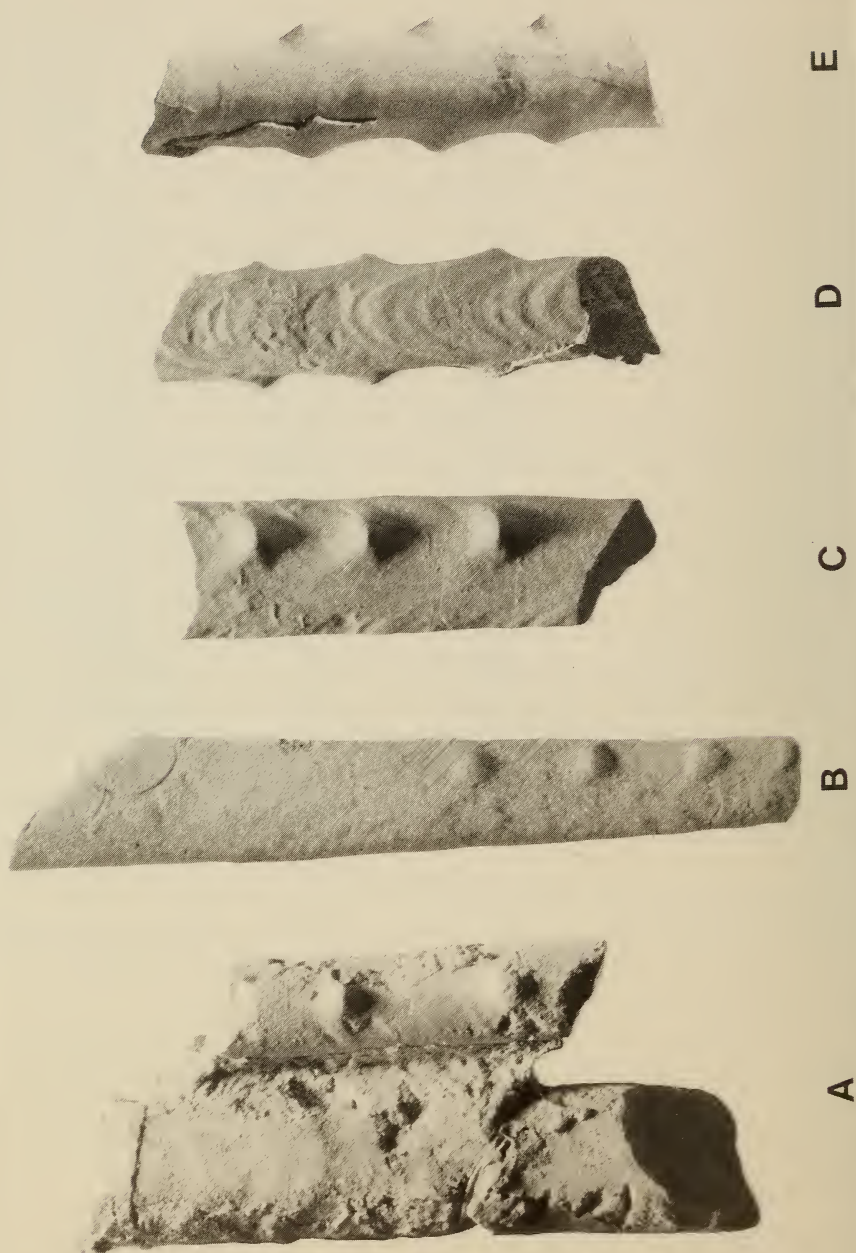


Fig. 54

maximum abundance are arranged in ascending order'. Our Zululand material partially confirms this, although the *B. schencki*-type of ornament is not as common here as in California. (According to Haggart (1984: 232) no further specimens of *B. boulei* or of *B. schencki* were collected in the Chico Formation.) Our material confirms that the stratigraphic ranges of these forms are largely overlapping.

Thus on stratigraphic grounds alone, there is no justification for formally separating *B. schencki*, *B. boulei* and *B. capensis*. We admit that, in some areas, one of the morphologies may be more common, but if different morphologies are to be the criterion for separating *B. schencki* and *B. boulei* from *B. capensis*, then we may as well regard all the varieties of *B. capensis* described above as different species. We thus regard *B. schencki* and *B. boulei* as synonyms of *B. capensis*. A case could be argued to refer to *B. schencki*, *B. boulei* and *B. capensis* as early, intermediate and typical forms but, as noted above, these morphologies are partly co-eval, and this terminology would be confusing.

B. Western Interior of North America. In his original description of *B. capensis*, Woods (1906: 343) remarked on the similarities between the former and *B. asper* Morton (1834: 43, pl. 1 (figs 12–13), pl. 13 (fig. 2)), stating that the latter differed 'in having larger and transversely elongated tubercles'. Spath (1921: 257) also referred to the resemblance between *B. capensis* and *B. asper*. According to Spath, the specimen figured by Meek (1876, pl. 39 (fig. 10a only)) and a specimen from Mississippi in the British Museum 'are close to the South African species in all characters but the suture line'. Matsumoto (1959: 125) also commented on the similarities between *B. capensis* and *B. asper*, concluding that it was 'probably a parallelism between the entirely separated biogeographic provinces'. Similarities between the two species were again referred to by Matsumoto & Obata (1963: 50).

Unfortunately, *B. asper* appears to be uninterpretable at present. According to Morton (1834: 44), *B. asper* was initially discovered by Mr Nuttall at Cahawba, Alabama, and later found by Mr Conrad at Prairie Bluff, also in Alabama. These localities are both appreciably younger than the Coniacian–Santonian range of *B. capensis*. Cahawba is in the Selma Chalk, which is Late Campanian, and the Prairie Bluff Chalk is Maastrichtian.

Reeside (1962: 116) mentioned that only one of Morton's specimens survived. This had a label in Morton's handwriting that states the locality as being Prairie Bluff—i.e. Maastrichtian. Reeside concluded that Conrad's locality data, accepted by Morton, was erroneous, and interpreted *B. asper* as a Coniacian, Santonian and early Campanian species.

Kennedy & Cobban (1991a: 72), on the other hand, regarded all the American Coniacian–Santonian records of '*B. asper*' non Morton as *B. codyensis*

Fig. 54 (see facing page). *Baculites capensis*, form 11. Compare with *B. sparsinodosus* Collignon, 1969. A. SAM-PCZ8022. B. SAM-PCZ9971. C–E. SAM-PCZ9972. All from rubble from excavations at locality 6, Zululand, St Lucia Formation, Santonian II–III to Campanian I; presumably from the Campanian. Note the absence of tubercles on the body chambers in A and B. All $\times 1$.

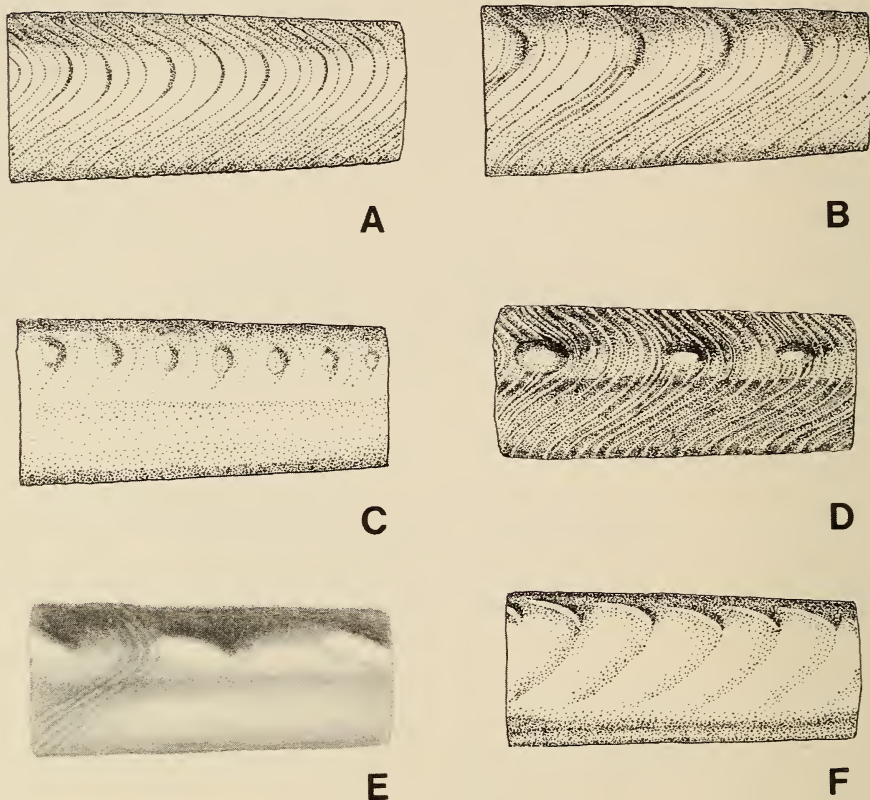


Fig. 55. *Baculites capensis* Woods, 1906. Suggested evolution of ornament, from *B. yokoyamai* (A), through *B. brevicosta* (B), *schencki* (C), *boulei* (D), to typical *capensis* (E) and *umsinenensis* (F), and ultimately to *B. menabensis* type (Fig. 57) (see p. 93).

Reeside (1927a: 4, pl. 2 (figs 6–19)). Typical forms of *B. codyensis* are easily distinguished from all varieties of *B. capensis*. These have crescentic, rib-like lateral tubercles, which may be projected prominently over the venter, superficially resembling *B. sulcatus*. Atypical forms of *B. codyensis*, previously misidentified as *B. asper*, have strong, distant bullae and a stouter whorl section (see e.g. Kennedy & Cobban 1991a, pl. 16). These are identical to some of our *B. capensis*, referred to as form 6 (see e.g. Fig. 43A–H, 47A–F) by their strong, crescentic dorsolateral tubercles. Even though some representatives of *B. capensis* and *B. codyensis* appear identical, the populations as a whole are very distinctive. No known specimens of *B. capensis* ever develop as strong and regular crescentic lateral ribbing as in typical *B. codyensis*, and no forms of *B. codyensis* ever develop longitudinally elongated lateral tubercles and a slight depression at mid-flank as in typical *B. capensis*.

An as yet unnamed baculitid fauna from the Upper Turonian–Lower Coniacian of Mossamedes, Angola, collected by Dr M. R. Cooper and now in the collections of the S.A. Museum, is of interest in apparently linking smooth

B. yokoyamai and ornate *B. codyensis*. These specimens all have dorsolaterally situated, closely spaced, crescentic tubercles (Figs 131N-R, 132A-F). These are very similar to our form 3 or *B. schencki*, and seem to suggest that acquisition of lateral ornament took place in a similar manner in both *B. codyensis* and

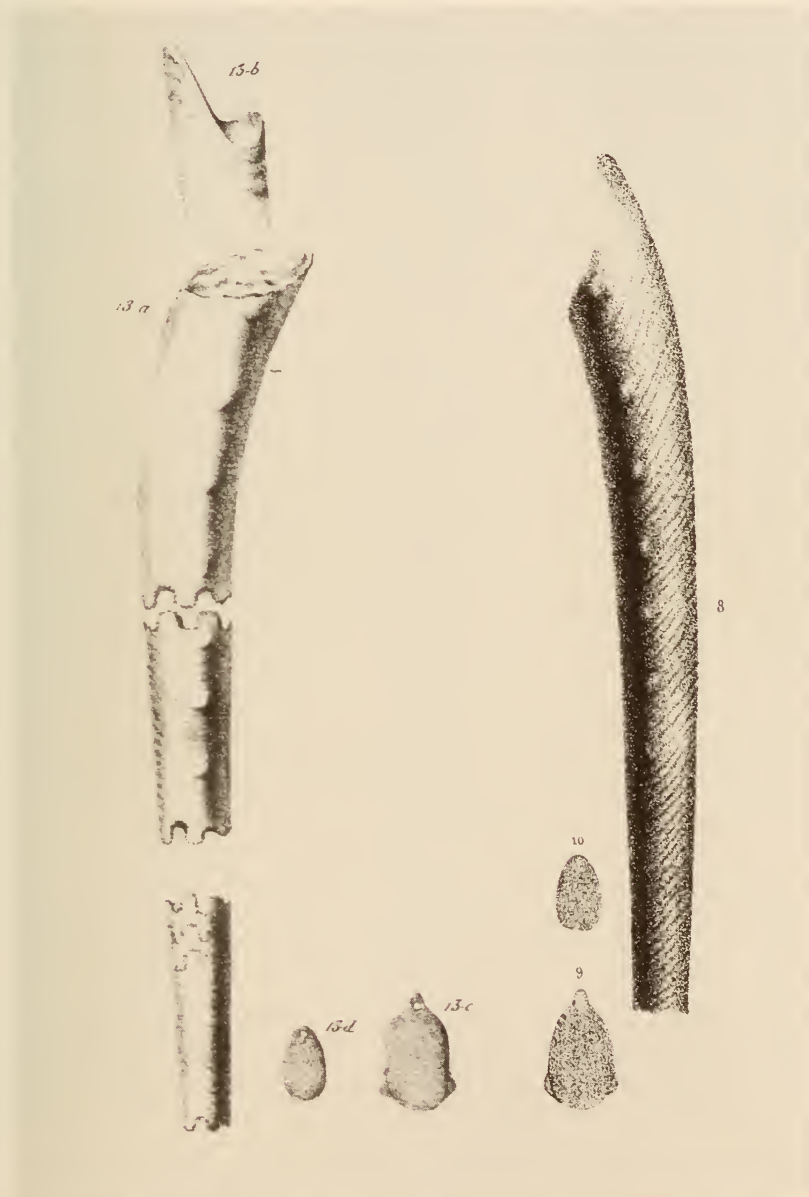


Fig. 56. *Baculites incurvatus* Dujardin, 1837. Numbers 13a-d: copy of Dujardin (1837, pl. 17 (figs 13a-d)). Numbers 8-10: copy of D'Orbigny (1842, pl. 139 (figs 8-10)). Note the apparent ventral keel in both figure 13c of Dujardin and figure 9 of D'Orbigny.

B. capensis, albeit at different times. Lateral ornament in the *B. codyensis* lineage first appears in the Lower Coniacian, whereas that of *B. capensis* occurs later, in the Middle or Upper Coniacian as shown by the Zululand and the Madagascan Mahagaga fauna.

C. European Region. Less easy to resolve are the relationship between the Indo-Pacific and the European nodose baculitids. In contrast to the Western Interior and the Indo-Pacific regions, baculitids are not as common in the European Tethys and are poorly preserved, and consequently the species are poorly known.

The relevant species are *B. incurvatus* Dujardin, 1837, and *B. brevicosta* Schlüter, 1876. The former name has, on occasions, been used indiscriminately for European *Baculites* with widely spaced nodes; the latter has been used for specimens with closely spaced, slightly oblique tubercles near the dorsolateral edge of the flanks.

Baculites incurvatus was recently reviewed by Immel *et al.* (1982), and Kennedy (1984), based on Austrian (Gosau) and French material respectively. Dujardin based this species on a series of fragments. The largest, a curved body chamber, was designated lectotype by Immel *et al.* (1982: 27). The lectotype (MNHP R1025a) and paralectotypes (MNHP R1025b-c (?e in WJK p. 143)) were refigured by Kennedy (1984, pl. 33 (figs 4-6, 15, 19-22)).

It is difficult to reconcile Dujardin's original figures (herein Fig. 56-13a-d) and descriptions on the one hand, and the type material on the other. Dujardin (1837: 232) gave the following diagnosis: 'Testa vaginaeformi, compresa, versus basim aliquantum incurvata; dorso nunc carinato, nunc rotundo, rugoso aut laevi, utrinque tuberculis evanescentibus instructa'. In his illustrations, two whorl sections are figured. The smaller (pl. 17 (fig. 13d)) is distinctly ovoid, but the larger (pl. 17 (fig. 13c)) shows distinct lateral sulci on either side of the venter, suggesting either a ventral keel, or a row of ventral (siphonal) tubercles—although the latter seems to be unlikely. If there were ventral tubercles on the body chamber, surely these would have shown up in the lateral view of the body chamber. The lectotype, MNHP R1025a, however, shows no trace whatsoever of a ventral keel.

Fig. 57 (*see facing page*). *Baculites menabensis* Collignon, 1969. Plaster cast of the holotype, GD 12036, the original of Collignon (1969, pl. 518 (fig. 2036)) from the Lower Campanian of gisement 307, km 15 600 Coupe Ampolypoly-Antsirasira-Behamotra (Belo sur Tsiribihina), Madagascar. x 1.

Fig. 58 (*see overleaf*). A-C. *Baculites falcatus* Collignon, 1969. Plaster cast of the holotype, GD 12045, the original of Collignon (1969, pl. 520 (fig. 2045)) from the Lower Campanian of gisement 303, km 15 000 Coupe Ampolypoly-Antsirasira-Behamotra (Belo sur Tsiribihina), Madagascar. D-F. *Baculites ventroplanus* Collignon, 1969. Plaster cast of the holotype, GD 12048, the original of Collignon (1969, pl. 520 (fig. 2048)) from the same locality as above. Both x 1.

Fig. 59 (*see overleaf*). A-C. *Baculites antsirasiraensis* Collignon, 1969. Plaster cast of the holotype, GD 12040, the original of Collignon (1969, pl. 519 (fig. 2040)) from the Lower Campanian of gisement 304, km 15 200 Coupe Ampolypoly-Antsirasira-Behamotra (Belo sur Tsiribihina) Madagascar. D-F. *Baculites subtilis* Collignon, 1969. Plaster cast of the holotype, GD 12042, the original of Collignon (1969, pl. 519 (fig. 2042)) from the same locality as above. Both x 1.



Fig. 57

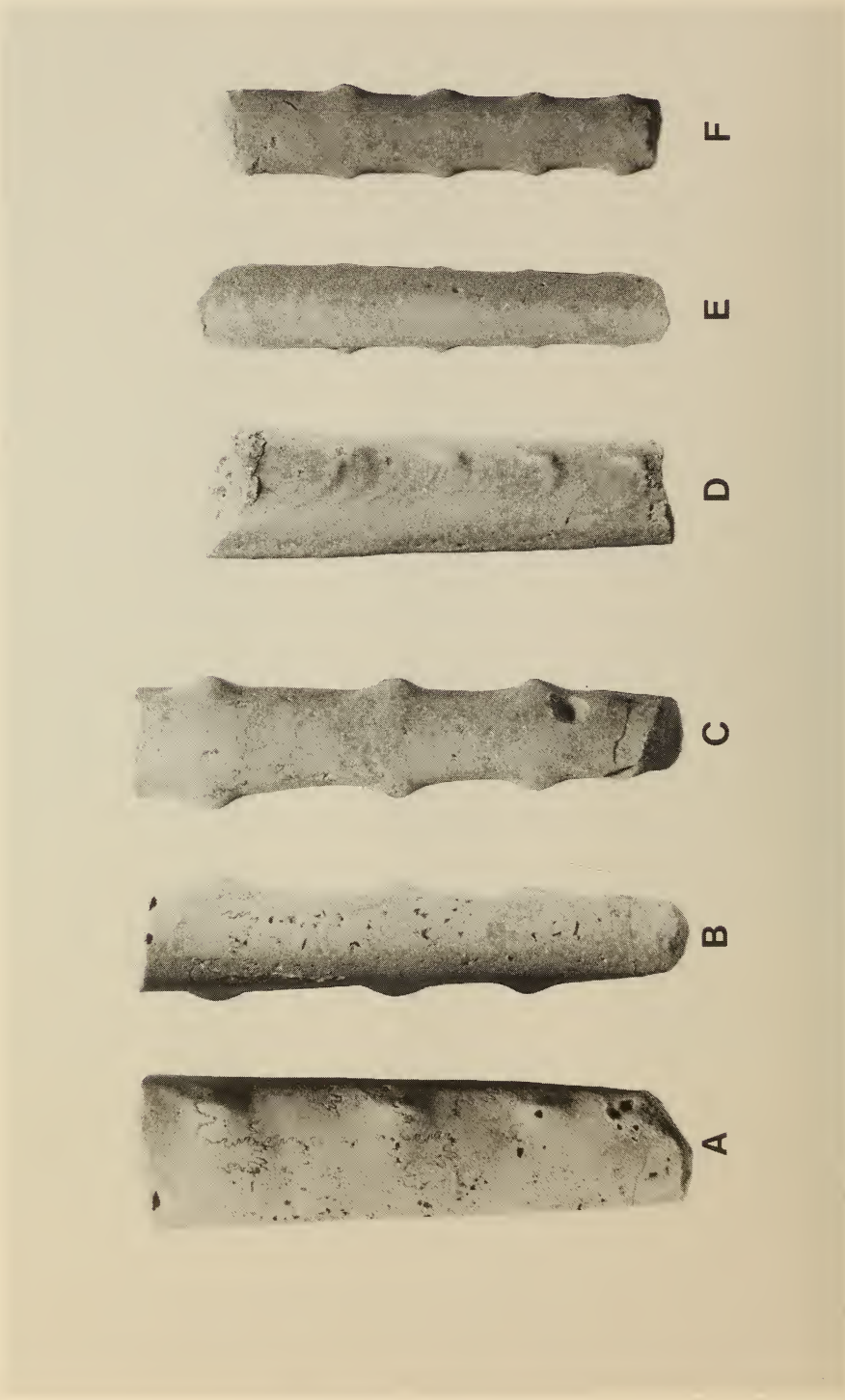


Fig. 58

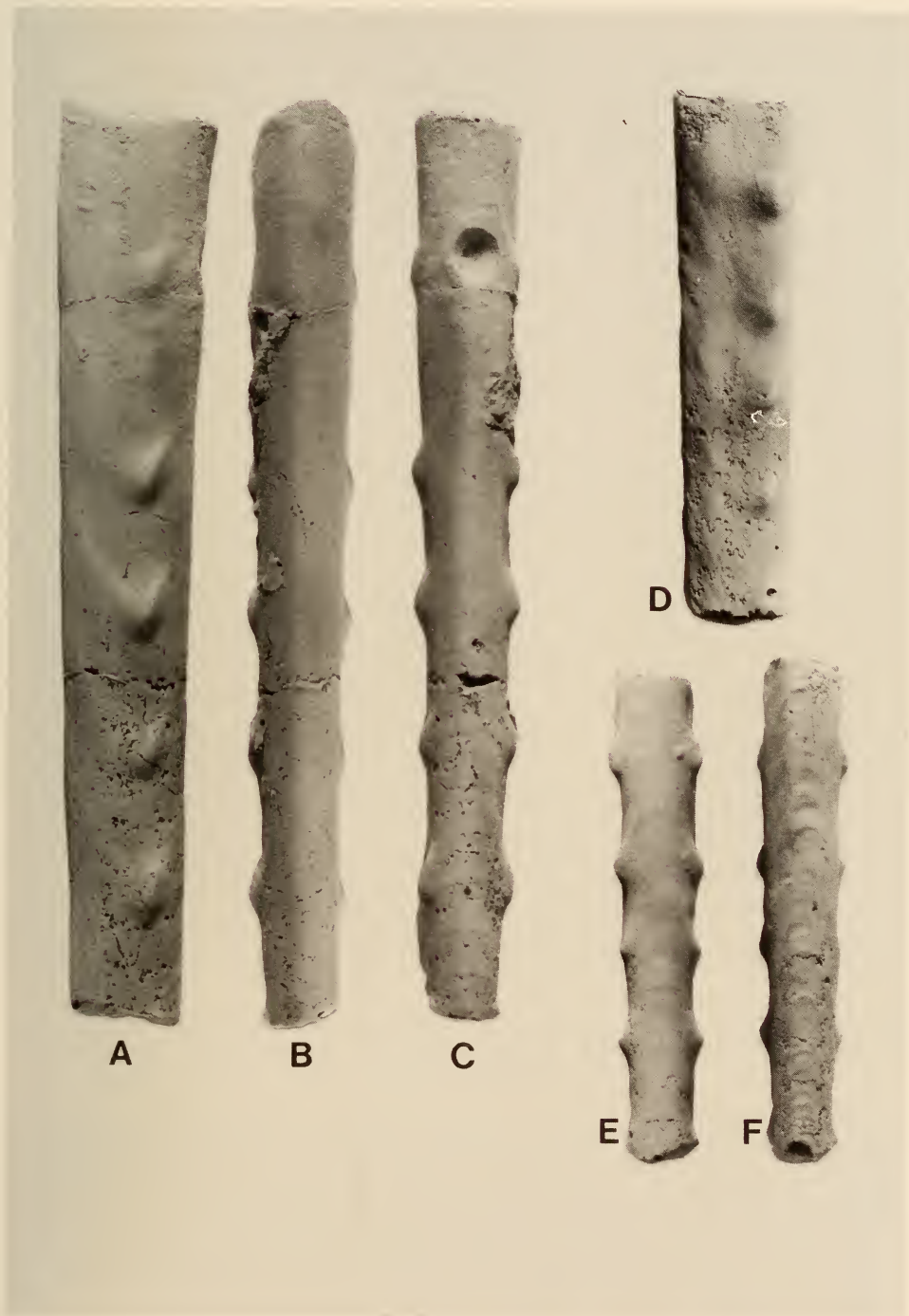


Fig. 59

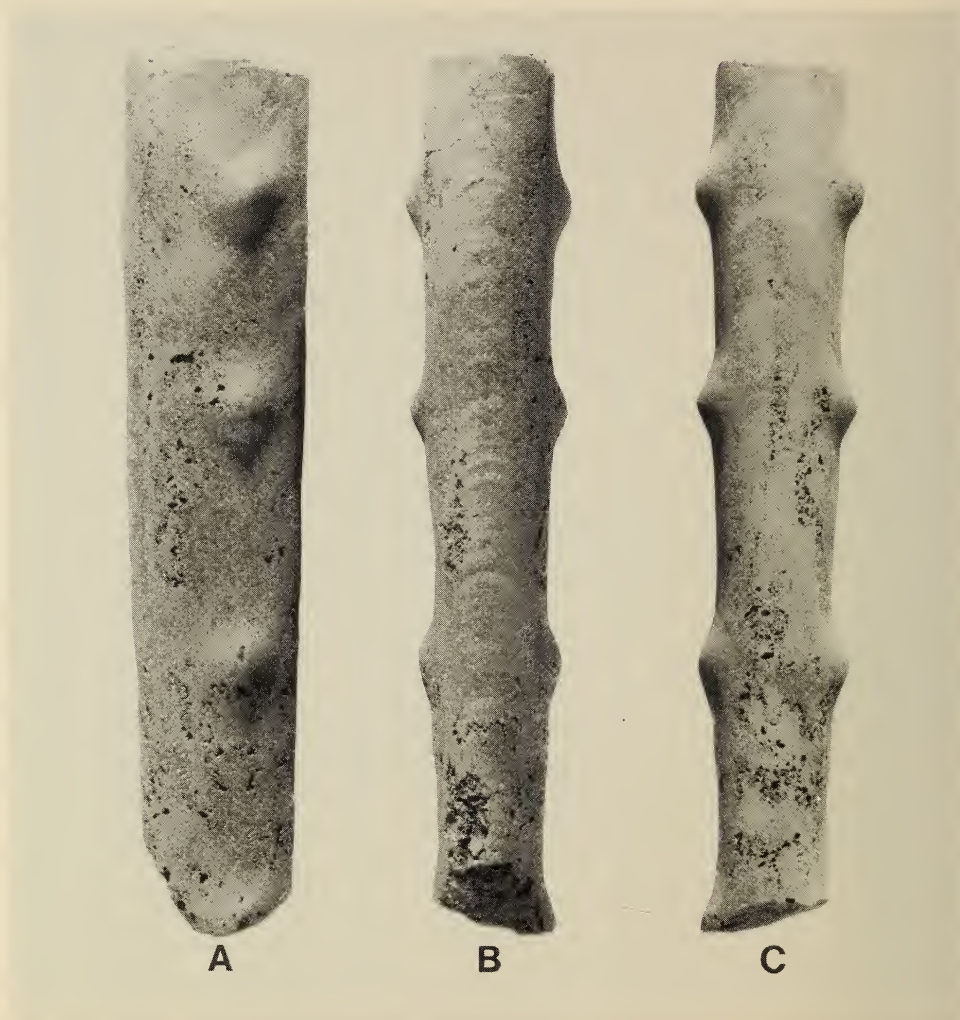


Fig. 60. *Baculites sparsinodosus* Collignon, 1969. Plaster cast of the holotype, GD 12052, the original of Collignon (1969, pl. 521 (fig. 2052)) from the Lower Campanian of gisement 302, km 14 200, Coupe Ampolypoly-Antsirasa-Behamotra (Belo sur Tsiribihina), Madagascar. $\times 1$.

D'Orbigny's (1842: 564, pl. 139 (figs 8–10)) (herein Fig. 56–8–10) subsequent description and illustration of *B. incurvatus* is better known than that of Dujardin. Again, D'Orbigny's figure shows a baculitid with a curved body chamber, and a whorl section that is ovoid on the phragmocone, but distinctly carinate on the body chamber. Two specimens in D'Orbigny's collection, presumably used in his reconstruction of *B. incurvatus*, survive and were refigured by Kennedy (1984, pl. 33 (figs 1–3, 16–18)). Neither shows any trace of a ventral keel. We suspect that D'Orbigny's figure of *B. incurvatus* may have been based more on Dujardin's original figures than on his own material.

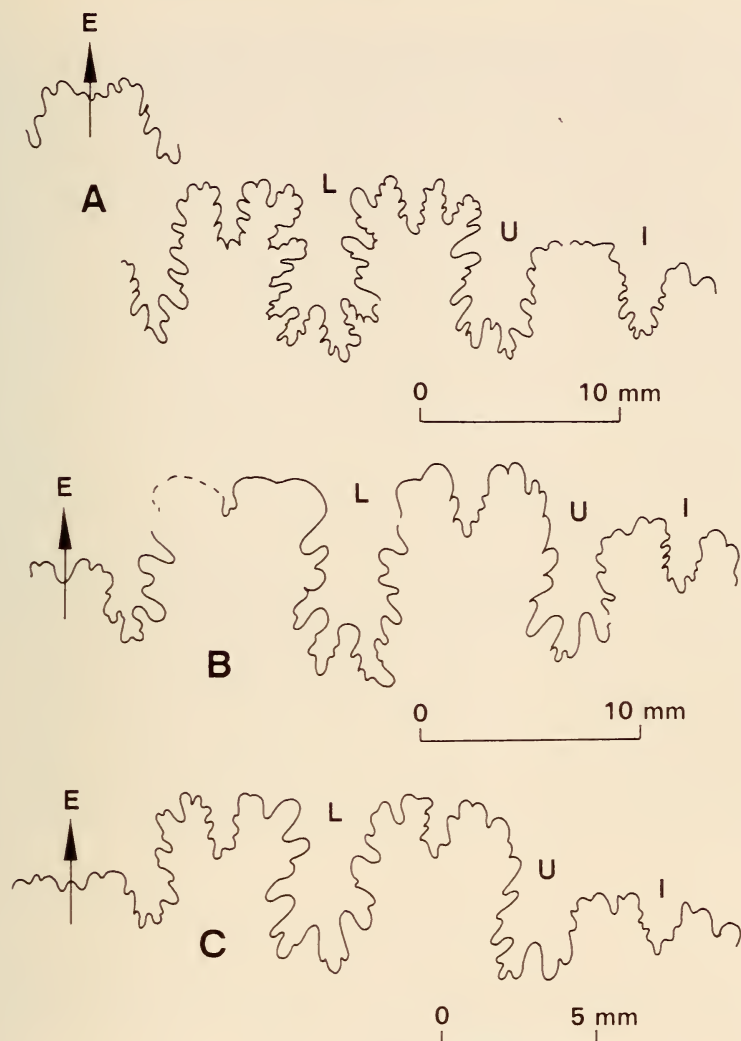


Fig. 61. Suture lines. A. *Baculites sparsinodosus*. Collignon, 1969 (see Fig. 60). B. *Baculites falcatus* Collignon, 1969 (see Fig. 58A-C). C. *Baculites subtilis* Collignon, 1969 (see Fig. 59D-F). Scale bar for size.

Subsequent interpretations of *B. incurvatus* are confused. Meek (1876: 392) divided the genus *Baculites* into two groups. His group b was defined as follows: '?b. Shell straight posteriorly, but with the non-septate part gently arcuate; aperture a little oblique; appendage of siphonal side of lip arching slightly with the general curvature of the non-septate part, but not curving over the aperture—(*B. incurvatus* Dujardin)'. Spath (1926: 80) subsequently introduced the new baculitid genus *Euhomaloceras* as follows: 'the new genus *Euhomaloceras* gen. nov. is proposed for Meek's group b (Invertebr. Cret. and Tert. Fossils, *U.S. Geol. Surv. Territ.*, vol. ix, 1876, p. 392) with *B. incurvatus*

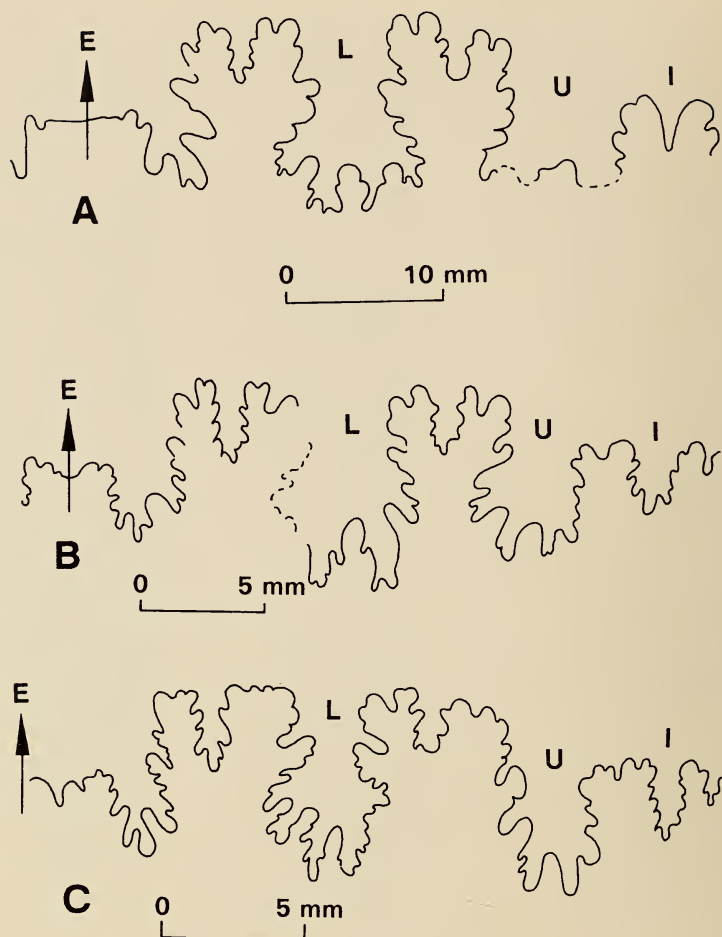


Fig. 62. Suture lines. A. *Baculites ambatryensis* Collignon, 1971 (see Fig. 128). B. *Baculites antsirasiraensis* Collignon, 1969 (see Fig. 59A-C). C. *Baculites menabensis* Collignon, 1969 (see Fig. 57). Scale bar for size.

Dujardin (in D'Orbigny, *Pal. Franc., Terr. Cret.*, vol. 1, 1842, p. 564, pl. 139 (fig. 8)) as genotype.' Spath's concept of *Euhomaloceras* is difficult to interpret. Both Dujardin and D'Orbigny's figures show a curved body-chamber, and it was this feature that defined Meek's group b; Meek did not refer to the whorl section at all. Wright (1957: L218) provided the first, and only diagnosis of *Euhomaloceras* as: 'Bodychamber gently curved with distinct rounded siphonal and laterodorsal tubercles.' The mention of siphonal tubercles is based on a misinterpretation of the cross section in the figures of Dujardin and D'Orbigny.

Fig. 63 (see facing page). *Baculites sulcatus* Baily, 1855. A-B. BMNH C35625, the lectotype, and impression of paralectotype, from an unrecorded horizon at locality 1, Pondoland, Mzamba Formation—presumably from the upper parts of the section, Campanian ?l. $\times 5$. Photograph courtesy of Natural History Museum, London.

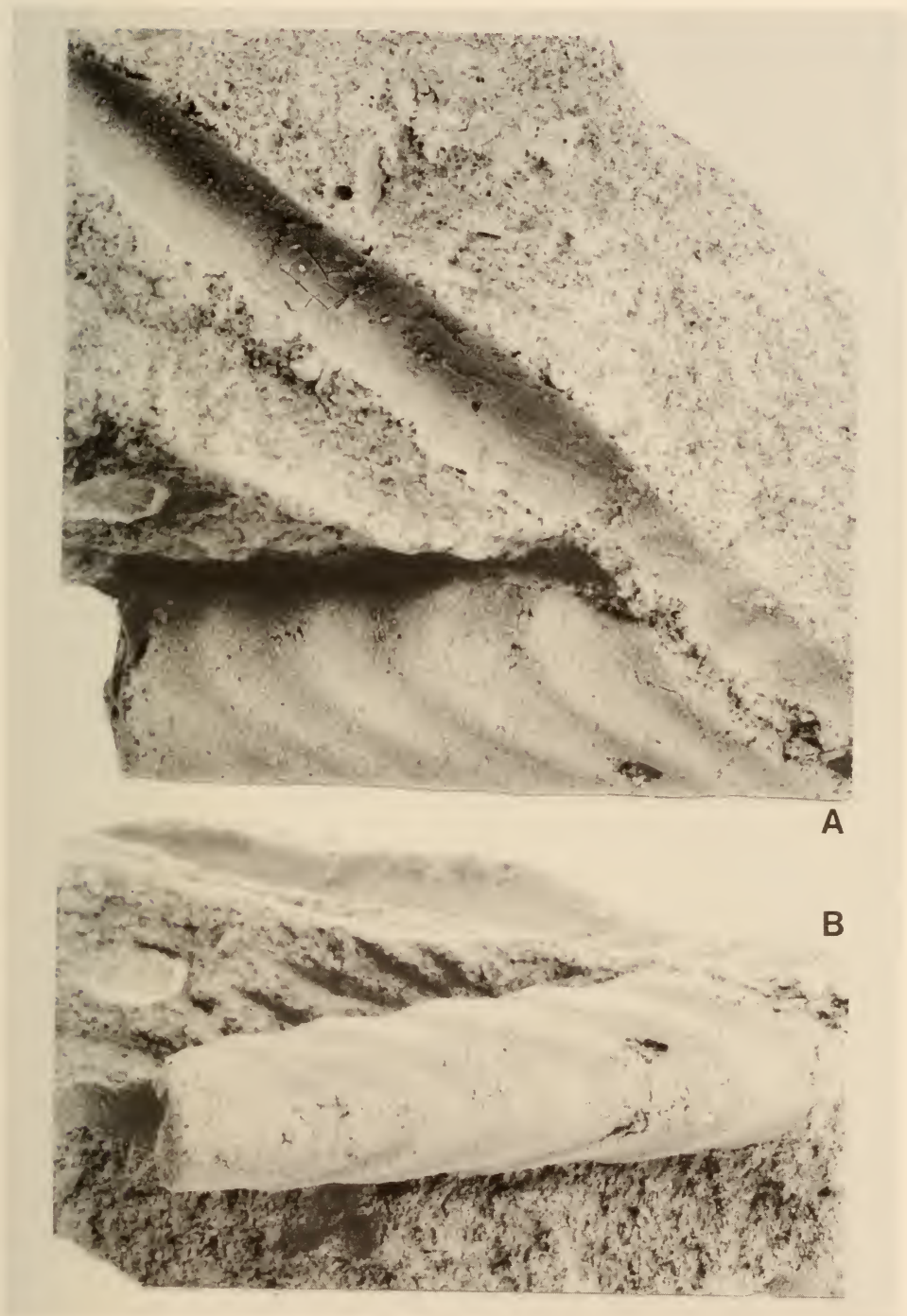


Fig. 63

Subsequent examination of *Baculites* has shown that curvature of the body chamber is a very variable and inconsistent feature, and is certainly not of generic significance. The name *Euhomaloceras* is thus unnecessary as discussed by Immel *et al.* (1982: 27–28).

As mentioned above, none of the surviving specimens on which Dujardin and D'Orbigny based their figures shows any indications of a ventral keel on the body chamber. Why both Dujardin and D'Orbigny figured a ventral keel on the body chamber of *B. incurvatus* remains a mystery. We suspect that Dujardin may have erred, and that D'Orbigny's artist merely copied the error.

In France, *B. incurvatus* first occurs in the Middle Coniacian in Touraine and Aquitaine, and persists through the Upper Coniacian into the Santonian, a stratigraphic range nearly identical to that of *B. capensis*. In Austria it occurs in the Lower Santonian.

Younger Campanian records of *B. incurvatus*, e.g. Holzapfel (1887: 64, pl. 4 (figs 5–6), pl. 5 (fig. 10)) from the Vaals Formation at Aachen, Germany; Müller & Wolleermann (1906: 4, pl. 2 (figs 2–5)) from Braunschweig and Broitzem in northern Germany, and Collignon (1938: 88, pl. 6 (figs 4–5)) from the Campanian of Andimaka in Madagascar, are all probably misidentifications. The specimens referred to *B. incurvatus* by Holzapfel and Müller & Wolleermann were considered the same as *Baculites* sp. 1 by Kennedy (1986b: 110, pl. 17 (figs 7–9, 13–15, 21–23), pl. 18 (figs 18–22), pl. 23 (figs 1, 7), text-fig. 8A–C), from the Upper Campanian of France. However, Müller & Wolleermann's specimens show distinct longitudinally to obliquely elongated tubercles, whereas Kennedy's *Baculites* sp. 1 has transversely elongated tubercles. In this respect, the German specimens seem closer to some of the baculitids from the Lower Campanian of Madagascar described by Collignon (1969); all are probably synonyms of *B. menabensis* Collignon or *B. tanakae* Matsumoto & Obata, 1963, as discussed below (p. 109).

The Campanian *B. incurvatus* of Collignon (1938) has a distinct trigonal whorl section and is closer to *B. bassei* Besairie or *B. nibelae* sp. nov., to be described below.

Fig. 64 (*see facing page*). *Baculites sulcatus* Baily, 1855. Typical forms. A. SAM-7043. Specimen on back of block with *Hauericeras* figured by Klinger & Kennedy (1980, fig. 5b), collected by T. Gevers from the top bed, T2. B–D. SAM-PCP5695. E–G. SAM-PCP5684. H–I. BMNH C35625, the lectotype. J. SAM-PCP8420. K. SAM-PCP8656. L–N. SAM-PCP5684. A–G, J–N, all from the top beds at Mzamba Cliff, Pondoland, Mzamba Formation, Campanian I. A–D, H–N $\times 1$; E–G $\times 2$.

Fig. 65 (*see overleaf*). *Baculites sulcatus* Baily, 1855. All weakly ornamented forms. A–C. SAM-PCP8653. D–F. SAM-PCP8361. G–H. SAM-PCP8656. I–K. SAM-PCP8153b. L–N. SAM-PCP8422. O–Q. SAM-PCP8153. R. SAM-PCP8660. All from the upper beds at the type section of the Mzamba Formation, Campanian I. All $\times 1$.

Fig. 66 (*see overleaf*). *Baculites sulcatus* Baily, 1855. Early forms—Van Hoepen collection, Transvaal Museum. A–B. TM 540g. C–E. TM 548c. F. TM 540f. G–I. TM 548a (microconch with part of aperture preserved). J–L. TM 540a. M–O. TM 540b. O–P. TM 540d. All from an unspecified horizon at locality 1, Pondoland, Mzamba Formation, presumably below the level of typical forms figured in Figures 64–65. All $\times 1$.

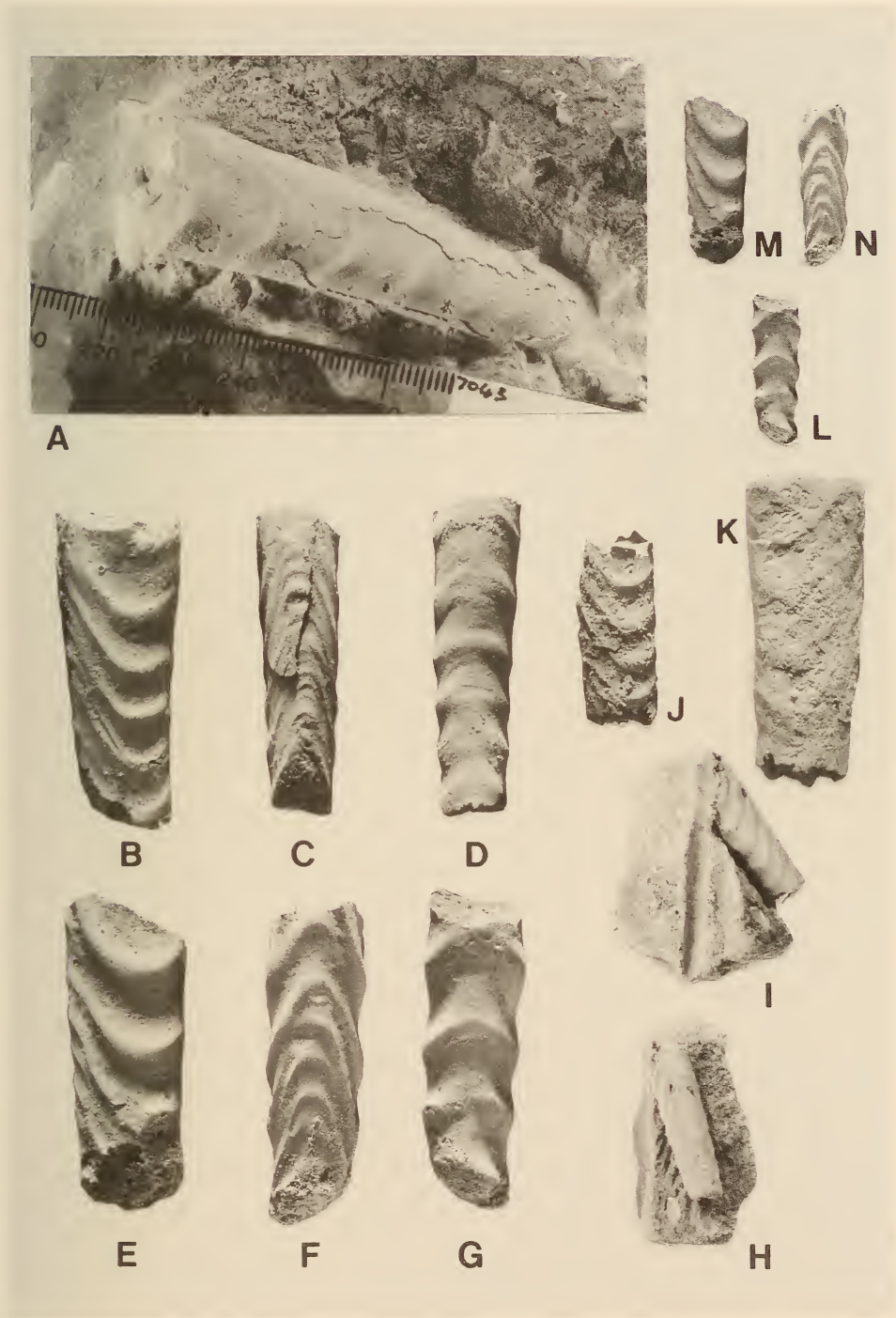


Fig. 64

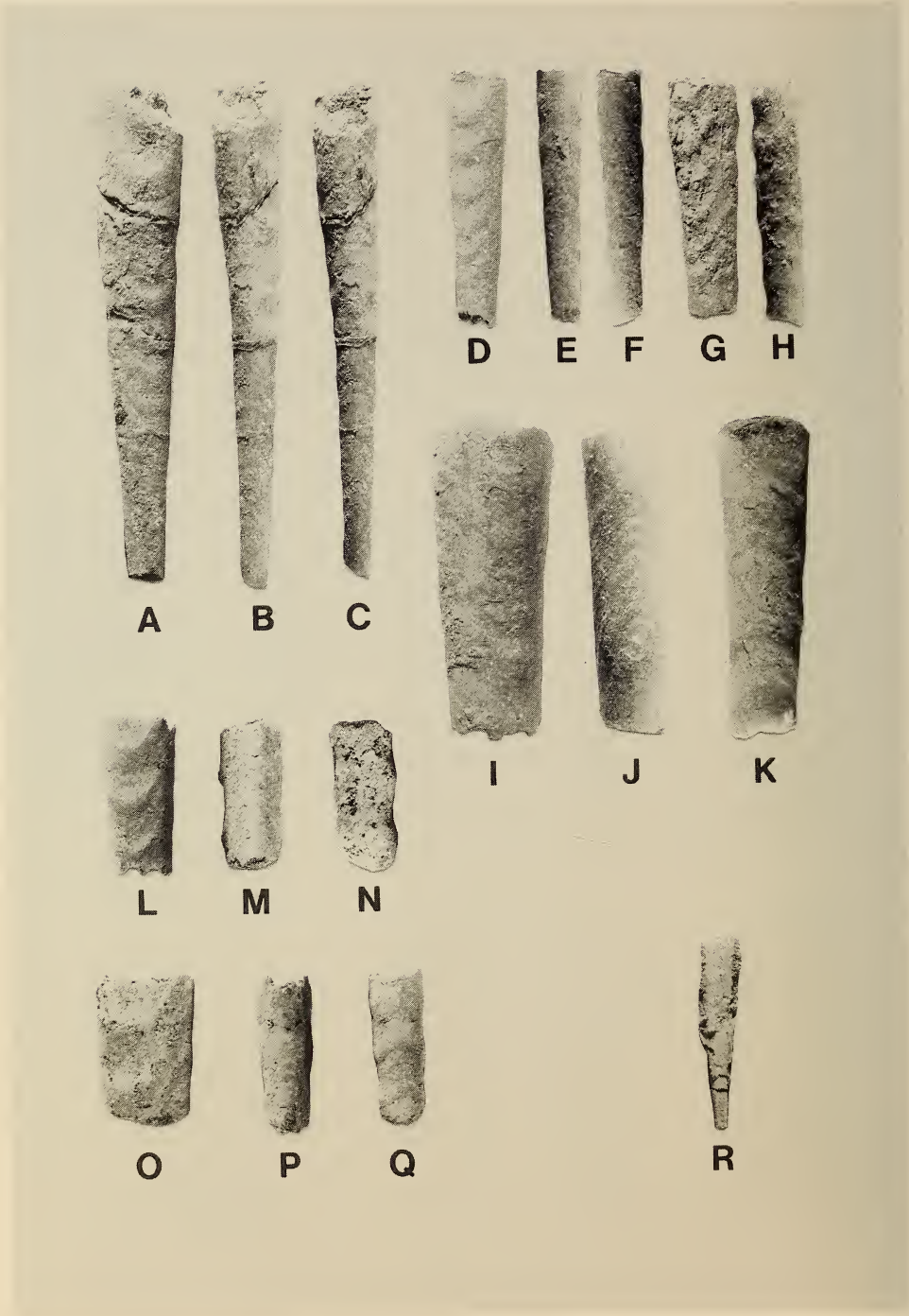


Fig. 65



Fig. 66

It is difficult to distinguish satisfactorily between *B. capensis* and *B. incurvatus*. Curvature of the body chamber, initially used to separate *B. incurvatus* (as *Euhomaloceras*) from the other baculitids, is of little significance, and indeed is shown only by the lectotype and by one other specimen figured to date (Kennedy 1984, pl. 33 (figs 4–6, 7–9)). Curved and straight body chambers occur in both species; occurrence of curved body chambers is apparently random.

As Woods (1906: 342) had already noticed, typical *B. capensis* differs from *B. incurvatus* by the longitudinal elongation of the tubercles, and by the presence of a shallow sulcus at mid-flank. A single specimen of *B. incurvatus* figured by Kennedy (1984: 143, pl. 33 (12–14)) has doubled tubercles and a shallow lateral groove, which, apart from being smaller, is very similar to Collignon's (1966: 7, pl. 457 (fig. 1865)) *B. malagasyensis*, here regarded a synonym of *B. capensis* s.s. Apart from this specimen, which was regarded by Kennedy as possibly being pathologic, no specimens of *B. incurvatus* are as yet known with typical *B. capensis* ornament.

However, the majority of specimens of *B. capensis* with rounded, conical or slightly crescentic tubercles are indistinguishable from contemporary *B. incurvatus*.

Woods (1906: 342), Spath (1921: 257–258) and Matsumoto (1959: 125) all commented on minor differences in suture lines of *B. capensis* and *B. incurvatus*. We can see absolutely no significant difference between the sutures of *B. capensis* and *B. incurvatus* (Kennedy 1984, text-fig. 42F–H).

Immel *et al.* (1982: 28) also considered the whorl sections to be different—that of *B. capensis* being more elliptical, with wide venter and flat flanks. Again, typical forms of *B. capensis* do have elliptical whorl sections, but many have whorl sections indistinguishable from those of known *B. incurvatus* (see Figs 30, 31).

It is interesting to note that some specimens of *B. incurvatus* are virtually smooth and lack tubercles, and show a similar range of variation in this respect as *B. capensis*.

Clearly, on the basis of the disparate sizes in population of *B. capensis*—numbering several hundred specimens, and *B. incurvatus*—numbering perhaps 30 specimens, no final decision can be taken as to whether *B. capensis* should be regarded as a junior synonym of *B. incurvatus*. However, given their similar ages, but apparent geographic separation, it might eventually be feasible to regard them as a subspecies (of *B. incurvatus*).

Fig. 67 (see facing page). A–D, H–N. *Baculites sulcatus* Bailey, 1855. Early forms. Van Hoepen Collection, Transvaal Museum. Smooth to weakly ribbed specimens. A–B. TM 548a. Microconch with aperture. C–D. TM 548e. H–J. TM 548d. Microconch with complete aperture. Note long, slightly inwardly-curved linguiform ventral rostrum and short, outwardly-curved dorsal rostrum. All from an unspecified horizon at locality 1, Pondoland, Mzamba Formation, presumably below the level of typical forms figured in Figure 64. E–G. *Baculites furcillatus* (Blanckenhorn, 1905). SAM-PCI8573 from the Campanian of Israel (ex Z. Lewy collection). K–Q. *Baculites bailyi* Woods, 1906. K–L. SAM-PCP6766. M. SAM-13103. Specimen from Geological Commission collection, one of Woods' paratypes of *B. bailyi*. N. SAM-PCP6765. O–Q. SAM-PCP8729, all from the basal beds at locality 1, Mzamba Formation, Santonian II. A–J, M $\times$ 1; K–L, N–Q $\times$ 2.



Fig. 67

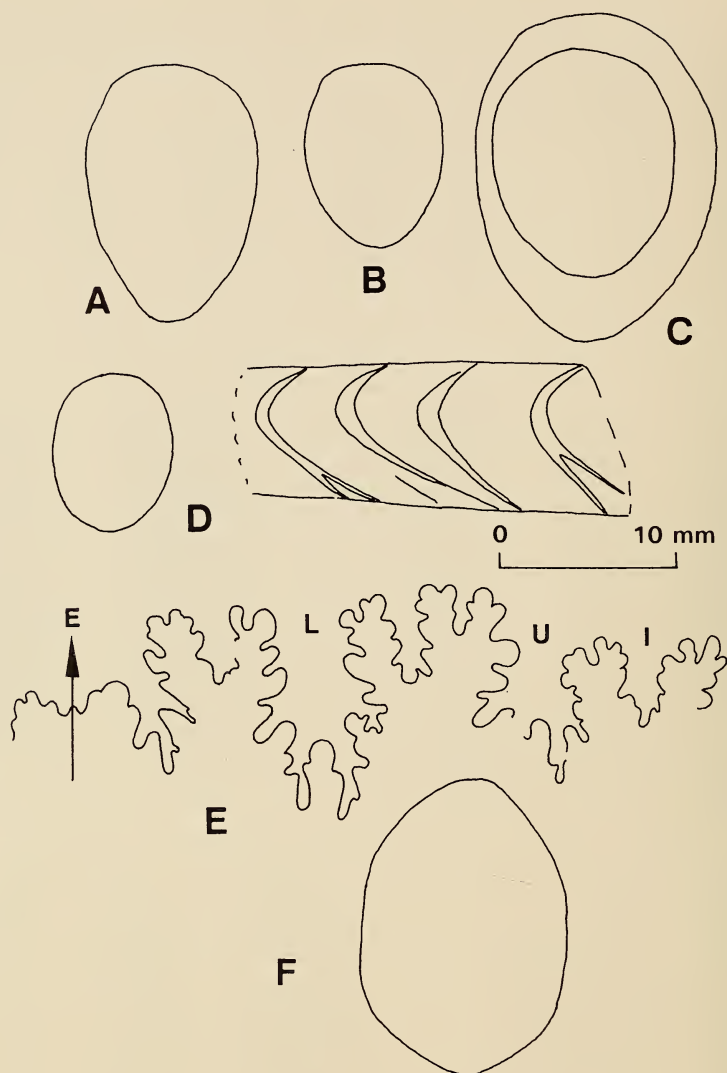


Fig. 68. *Baculites sulcatus* Bailey, 1855. Typical form. Whorl sections, suture line and ornament. A. SAM-PCP8421. B. SAM-PCP8420. C. SAM-PCP5685. D. SAM-PCP5684. E. SAM-PCP8421. F. SAM-PCP8419. Venter in whorl sections pointing downward. Scale bar for size.

The other European baculitid that falls within the morphological limits of *B. capensis* is *B. brevicosta* Schlüter. Unfortunately, the only unequivocal record of this species is the original description from northern Germany given by Schlüter (1876: 141, pl. 39 (figs 9–10)). Schlüter based this species on several specimens (not just two as claimed incorrectly by Kennedy 1984: 146). The original of Schlüter (1876, pl. 39 (figs 9–10)) was designated lectotype by

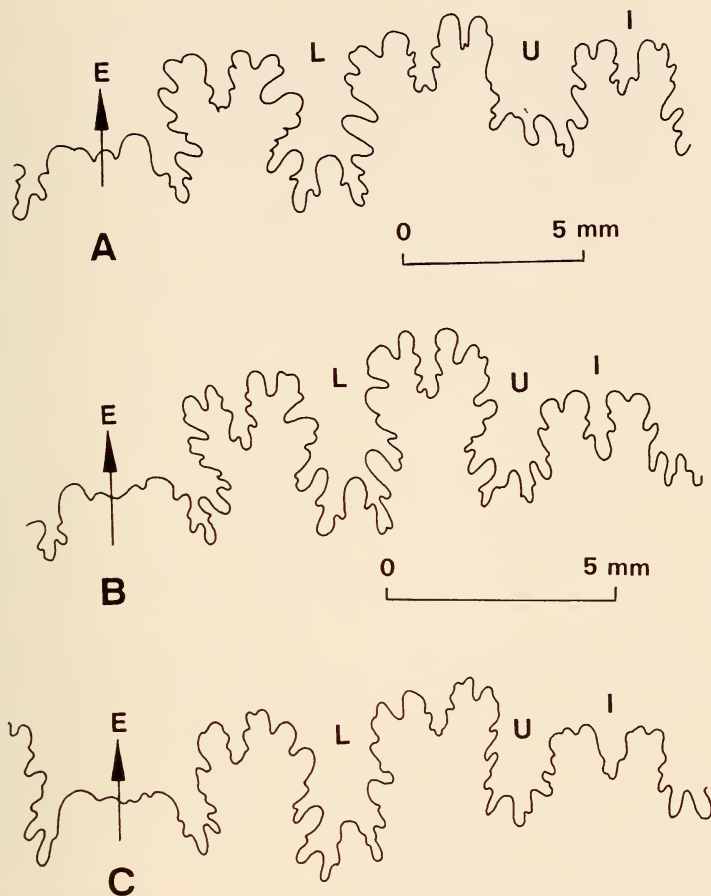


Fig. 69. *Baculites sulcatus* Bailey, 1855. Typical form. Suture lines.
 A. SAM-PCP8152. B. SAM-PCP8153. C. SAM-PCP8661.
 Scale bar for size.

Kennedy (1984: 146). Unfortunately, neither the lectotype nor any of the other paralectotypes could be traced by us in the collections in Bonn, and we have to assume that they are lost.

Subsequent records of *B. brevicosta* all have to be viewed with caution. The specimens from the Lower Senonian of Sweden (with *Actinocamax quadrata*) from Eriksdal, Sweden, described and figured by Möberg (1885: 37, pl. 4 (figs 5–6)) have very weak, crescentic lateral ribs, rather than dorsolaterally situated tubercles as in *B. brevicosta*, and they do not seem to belong to this species.

The specimens from Mkweyane (Umkwelane Hill), Zululand, described and figured by Spath (1921: 146, pl. 24 (fig. 5)) as *Baculites cf. brevicosta* are identical to Schlüter's figures, as also noted by Spath (1921: 260) 'since it probably only represents a variety of *B. capensis* . . . its exact agreement with Schlüter's species may be a case of heterochronous homoeomorphy'. The

relationship of this (Zululand) specimen to typical *B. capensis* is probably the same as that of European *B. brevicosta* to *B. incurvatus*. Their relative stratigraphic occurrences in France (Kennedy 1984) seem to confirm this.

Kaplan & Kennedy (1994: 59, pl. 40 (figs 15–19)) described and figured alleged *B. brevicosta* from the Coniacian of Westphalia. These show some *B. brevicosta* to have distinct ventral ribbing and weak lateral ornament, which places it closer to *B. undulatus* than to *B. capensis*. Nevertheless, it is still a rare species and the extent of variation is not fully known.

A closer analogue to *B. brevicosta* is *B. schencki* Matsumoto, 1959, as discussed above (see p. 87). *Baculites schencki*, here regarded as an early form of *B. capensis*, was said to differ from *B. brevicosta* merely by the strength of the tubercles (Matsumoto 1959: 117). The association of *B. schencki* and *B. capensis* is the same as that of *B. brevicosta* and *B. incurvatus*, thus further suggesting that the relationship of *B. capensis* and *B. incurvatus* is very close, and that separation at subspecific level only is probably justifiable.

In Zululand and Pondoland, the typical *B. capensis* lineage ends in the Middle Santonian, although some atypical forms (form 11, *B. sparsinodosus*?) may occur in the Lower Campanian of Zululand. These last representatives include typical *B. capensis* forms with longitudinally elongated tubercles, with the middle part of the flanks flat or slightly depressed and with a round or fastigate venter.

In Pondoland, *B. capensis* is succeeded by *B. sulcatus* in the Lower Campanian, and in Zululand by *B. increscens*–*B. vanhoepeni* in the Middle Campanian—both with typical rib-like or auricular lateral ornament. Morphologically these seem far removed from the *B. capensis* type of ornament.

Some of the baculitids from Pondoland, described as *B. sulcatus* by Van Hoepen (1921: 18, pl. 3 (figs 7–8)) and later referred to *Baculites vagina* var. *vanhoepeni* by Venzo (1936: 116 [58], pl. 10 [6] (figs 11–12)) (see Fig. 66), could possibly be seen as a link between *B. capensis* and *B. sulcatus* + *B. vanhoepeni* as is to be discussed below (p. 150).

Fortunately, Collignon (1969) has described a rich baculitid fauna from the Lower Campanian of Madagascar that seems to continue the *B. capensis* lineage. This fauna includes: *B. menabensis* Collignon (1969: 15, pl. 518 (figs 2036–7)) (herein Fig. 57); *B. antsirasiraensis* Collignon (1969: 18, pl. 519 (figs 2040–2041)) (herein Fig. 59A–C); *B. subtilis* Collignon (1969: 18, pl. 519 (figs 2043–2044)) (herein Fig. 59D–F); *B. falcatus* Collignon (1969: 20, pl. 520 (figs 2045–2046)) (herein Fig. 58A–C); *B. ventroplanus* Collignon (1969: 20, pl. 520 (figs 2048–2050)) (herein Fig. 58D–F) and *B. sparsinodosus* Collignon (1969: 23, pl. 521 (figs 2052–2054)) (herein Fig. 60). With the exception of *B. sparsinodosus*, all these species have dorsoventrally compressed, longitudinally elongated tubercles of the *B. capensis* type. They differ from typical *B. capensis* mainly in that the tubercles are more pinched, slightly oblique and situated nearer to the dorsum. Also, the whorl section becomes more compressed, and in some, e.g. *B. ventroplanus*, the venter becomes distinctly fastigate. The ornament of these Lower Campanian Madagascan species is nearly identical to that of form 9 or 'umsinenensis' type of *B. capensis*, which makes its first appearance in the Upper Coniacian of Zululand.

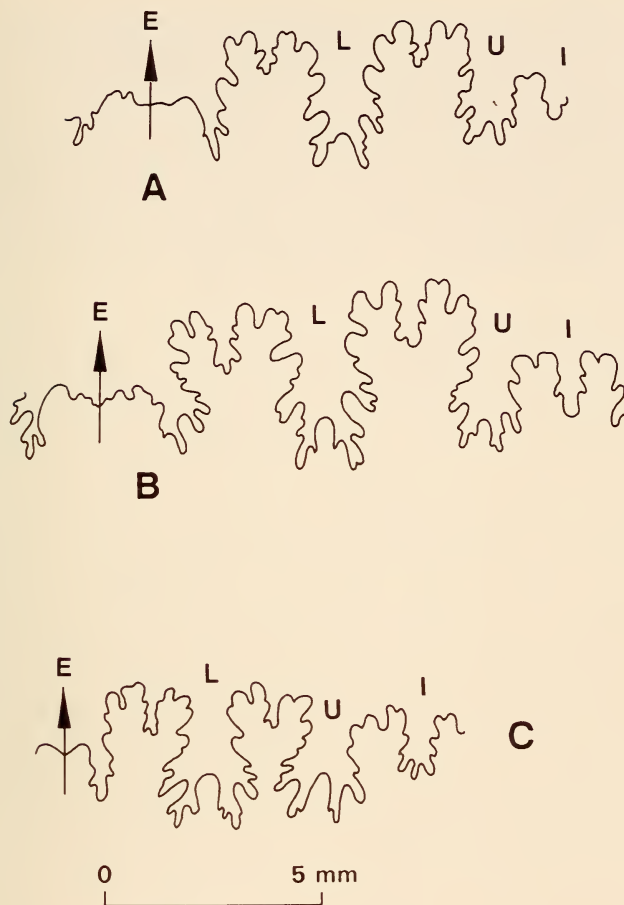


Fig. 70. *Baculites sulcatus* Baily, 1855. Suture lines. A. SAM-PCP12019. B. SAM-PCP8361. C. TM540m—note similarity to Woods' figured suture line of *B. bailyi* (1906, pl. 44 (fig. 5)). Scale bar for size.

With the possible exception of *B. sparsinodosus*, all these Lower Campanian Madagascan *Baculites* are probably synonyms; as first revising authors, we select *B. menabensis* as the name of this species.

As far as lateral ornament is concerned, Madagascan *B. menabensis* is indistinguishable from similarly dated specimens described as *B. incurvatus* from Braunschweig in Germany by Müller & Wollema (1906: 4, pl. 2 (figs 2–5)) and the Vaals Formation on the Belgian–Dutch border by Holzapfel (1887: 64, pl. 4 (figs 5–6)). More and precisely located material is needed to resolve the true identity of these European specimens.

Baculites tanakae Matsumoto & Obata (1963: 51, pl. 13 (fig. 4), pl. 16 (figs 1–5), pl. 17 (figs 1–5), pl. 18 (figs 1, 3–4), pl. 19 (figs 1, 4), text-figs 97–113, 115)) from the Lower Campanian of Hokkaido is probably a senior synonym of *B. menabensis* as here interpreted. According to Matsumoto & Obata

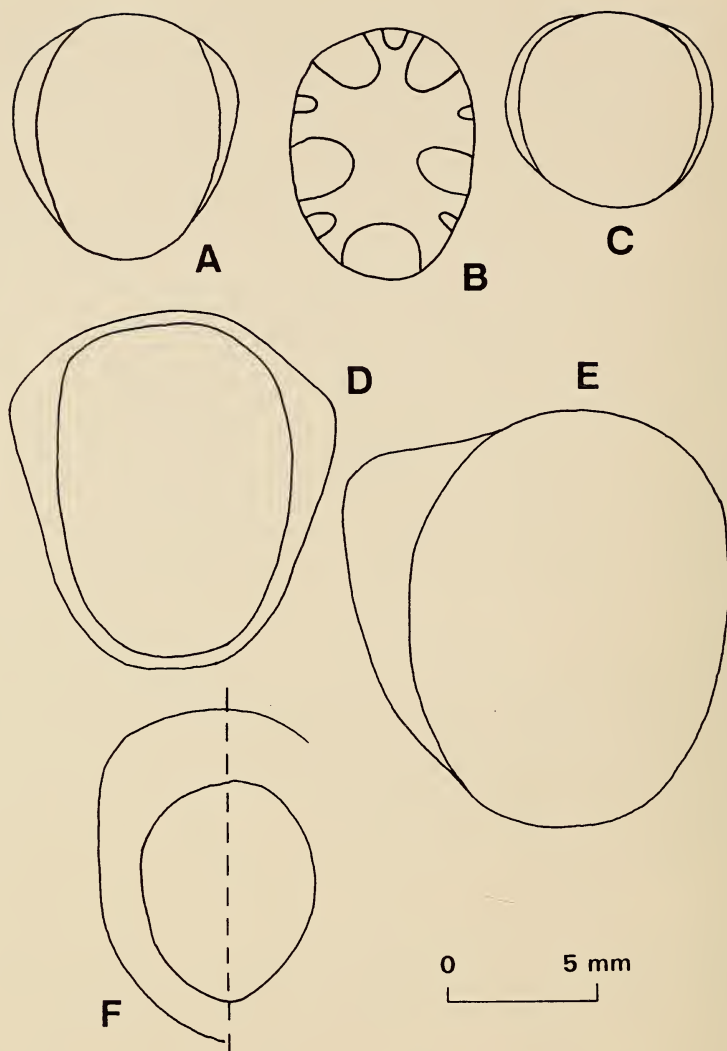


Fig. 71. *Baculites sulcatus* Baily, 1855. Early form. Whorl sections. A-B. TM 540g. C. TM 540h. D. TM 540a. E. TM 540b. F. TM 540c. Venter pointing downward. Scale bar for size.

(1963: 54), *B. tanakae* occurs above the beds with *B. capensis* in Hokkaido. The roof-shaped (fastigate) venter and the shape of the tubercles that varies from 'asymmetrically crescentic or obliquely elongated to longitudinally elongated, as in *B. capensis*' (Matsumoto & Obata 1963: 52-53) in *B. tanakae* is identical to that of the Madagascan *B. menabensis*. We can see no valid grounds for maintaining *B. tanakae* and *B. menabensis* as separate species.

Baculites tanakae differs from *B. capensis* by the fastigate venter, and the predominance of obliquely or longitudinally elongated tubercles that are situated higher up on the flanks than in typical *B. capensis*. As mentioned above, this

style of ornament is very similar to that of form 9 or var. '*umsinenensis*' in *B. capensis*. This seems to indicate that the first appearance of *B. tanakae*–*B. menabensis* type of ornament already occurs in the Upper Coniacian, but that dominance of this type of ornament only takes place much later, in the Lower Campanian. Unfortunately, we have no records of *B. capensis* from the Upper Santonian of Pondoland or Zululand, but we suspect that in Hokkaido, where the species occurs throughout the Santonian, specimens with this type of ornament should be found. Alternatively, the occurrence of '*umsinenensis*' type of ornament has to be regarded as iterative; we cannot say for sure.

Occurrence

Mainly Middle Coniacian to Middle Santonian of Zululand, but possibly also Lower Campanian, and Upper Coniacian to Lower Santonian of Madagascar, Middle Santonian of Pondoland, Santonian of Hokkaido and California, Upper Santonian of U.S. Gulf Coast, and, doubtfully, Lower Campanian in Angola.

Baculites sulcatus Baily, 1855

Figs 63–66, 67A–D, H–N, 68–77, 78C

- | | |
|----------|--|
| 1855 | <i>Baculites sulcatus</i> Baily, p. 457, pl. 11 (fig. 5c only, non 5a–b) (= <i>B. bailyi</i> Woods). |
| 1906 | <i>Baculites sulcatus</i> Baily; Woods, p. 341, pl. 44 (fig. 4). |
| 1921 | <i>Baculites sulcatus</i> Baily; van Hoepen, p. 18, pl. 3 (figs 7–8). |
| non 1921 | <i>Baculites</i> sp. cf. <i>sulcatus</i> Baily; Spath, p. 260 (= <i>B. capensis</i> Woods). |
| 1922 | <i>Baculites sulcatus</i> Baily; Spath, p. 146. |
| ? 1930 | <i>Baculites Bailyi</i> Woods; Besairie, p. 223, pl. 21 (fig. 6 only). |
| non 1931 | <i>Baculites sulcatus</i> Baily; Collignon, p. 36, pl. 5 (figs 3, 3a, 4, 4a, 5, 5a, 13, 13a), pl. 9 (fig. 15). (= ? <i>B. yokoyamai</i> Tokunaga & Shimizu). |
| non 1963 | <i>Baculites</i> n. sp. (?) aff. <i>B. sulcatus</i> Baily; Matsumoto & Obata, p. 46, pl. 12 (fig. 6), text-figs 94, 130. |
| 1977 | <i>Baculites sulcatus</i> Baily; Klinger & Kennedy, p. 75, figs 3B–E, J–L. |

Type

Baily (1855) apparently based this species on more than one specimen—Woods (1906: 341) refers to (the) ' . . . only specimens seen are the types . . . ' Matsumoto & Obata (1963: 46) claimed that Woods did not designate a lectotype. They accordingly designated the specimen figured in ventral view by Baily (1855, pl. 11 (fig. 5c)) as lectotype. However, Woods (1906, pl. 44 (fig. 4)) referred to this same specimen (which he figured in lateral view) in the plate explanation as 'The Type, Museum of the Geological Society of London'. In our view, this is a perfectly valid lectotype designation.

The lectotype, in the collections of the Natural History Museum, London, BMNH C35625 from an unspecified horizon at the type section of the Mzamba Formation at Mzamba Cliff is here refigured as Figures 63A–B, 64H–I.

Material

In addition to the lectotype, we have SAM-PCP5684, 5686, 8152–8154, 8361a, 8419–8422, 8653–7, 8660, SAM-7043, all from Bed A15 at locality 1

(see Klinger & Kennedy, 1980 figs 1-2), Pondoland, Transkei, Mzamba Formation, Campanian I; NMB D1663 from, an unspecified horizon at the same locality. In addition, we also have examined the material collected by Van Hoepen in 1919 and described in 1921, in the collections of the Transvaal Museum, TM 540a-g, 548a-c, all from an unspecified horizon at this locality. Recent excavations for a car park at the Wild Coast Casino a few kilometres north of the Mzamba Estuary, have yielded additional specimens (Cooper collection, MRC 1-39).

Dimensions

<i>Spec.</i>	<i>MxWb</i>	<i>MxWh</i>	<i>Wb/Wh</i>	<i>MnWb</i>	<i>MnWh</i>	<i>Wb/Wh</i>	<i>D</i>	<i>Ti</i>	<i>Ri</i>
PCZ8660	4.0	5.7	0.7	1.5	1.6	0.9	27	15.2	—
PCZ8361	6.2	8.6	0.72	4.1	5.5	0.74	32	9.7	2.5
PCZ5684	6.9	8.7	0.79	5.3	7.4	0.72	17	7.6	2.5
PCZ8656	7.0	10.0	0.7	5.0	6.9	0.73	31	10.0	3
PCZ8654	7.0	9.0	0.78	4.7	6.4	0.73	23	11.3	3
PCZ8153a	7.6	10.2	0.76	6.5	8.1	0.8	19	11.0	2.5
PCZ8421	7.7	9.8	0.79	6.7	8.0	0.84	18	10.0	—
PCZ8152	8.7	12.5	0.7	7.4	10.6	0.7	19	10.0	2-3
PCZ8420	9.0	11.0	0.82	7.5	10.0	0.75	24	4.2	3
PCZ8422	9.0	14.0	0.64	8.8	12.4	0.71	16	10.0	2.5
PCZ8419	11.2	15.3	0.73	8.3	11.7	0.71	38	9.5	—
PCZ8153b	12.3	17.0	0.72	9.1	13.0	0.7	39	10.2	2.5
D1663	10.7	14.9	0.72	8.0	11.0	0.73	34	11.5	3
TM 540e	7.0	8.4	0.83	5.7	7.1	0.8	36	3.6	—
TM 540c	7.2	9.8	0.74	5.6	7.9	0.71	28	6.9	—
TM 540a	8.0	10.6	0.75	6.0	7.2	0.83	38	8.9	2
TM 540g	8.0	11.0	0.73	7.0	9.0	0.78	27	7.4	2
TM 540b	12.6	16.7	0.75	10.0	13.2	0.76	42	8.3	0.5
MRC 6	7.0	11.0	0.64	—	9.0	—	34	5.9	2
MRC 28	8.0	10.0	0.8	6.0	7.0	0.86	24	12.5	2.5
MRC 13	9.3	13.0	0.71	7.7	10.7	0.72	26	8.8	2
MRC 12	11.0	13.0	0.81	—	—	—	—	—	—
MRC 8	11.0	14.9	0.79	8.0	11.0	0.73	35	8.6	0.5
MRC 7	14.0	19.0	0.74	12.0	17.0	0.71	46	4.3	0
MRC 1	19.0	24.0	0.79	14.0	19.0	0.74	67	7.5	2.5

Description

Lectotype. The lectotype is a small individual, 22 mm long with a whorl height of approximately 7 mm, partially embedded in soft, green silty matrix

Fig. 72 (see facing page). *Baculites sulcatus* Bailey, 1855. ?Late forms. A. MRC 24. B. MRC 6. C. MRC 9. D. MRC 18. E-F. MRC 17. G-H. MRC 7. Note slight curvature in A and E. All from excavation for new car park at Wild Coast Casino, Pondoland, Mzamba Formation, Campanian. All $\times 2$.

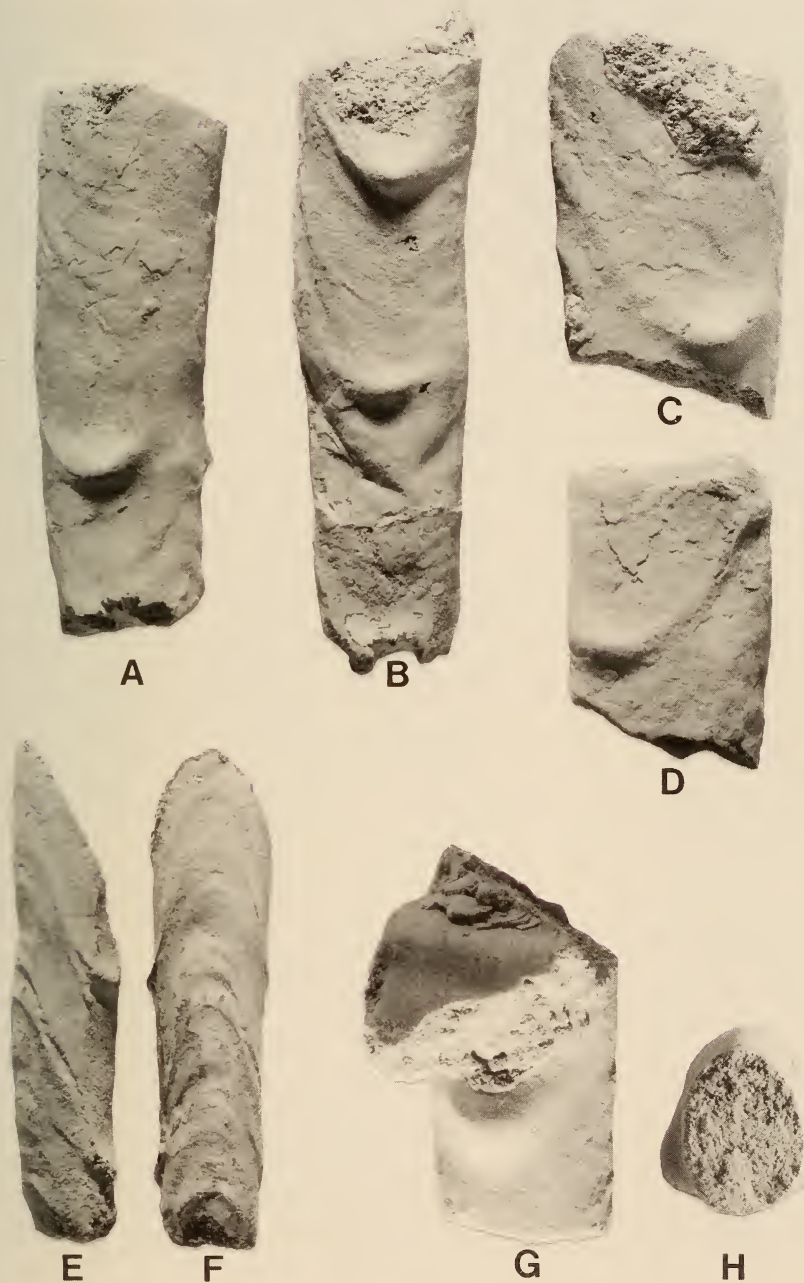


Fig. 72

(Figs 63, 64H-I). The main features are the strong lateral ornament. The ribs are crescentic, strongest on the dorsolateral part of the flanks, weaker on the lower half and sweep forwards over the venter, forming a distinct chevron. The impression of another (paralectotype) individual is present in the block of matrix.

Topotype material. The initial discovery of *B. sulcatus* by Capt. Garden was serendipitous. Detailed collecting by us yielded identical specimens only in the topmost beds at the Mzamba Cliff. However, the underlying beds are difficult to reach at this locality, and it is quite possible that *B. sulcatus* already occurs lower down in the section, probably above the Santonian-Campanian boundary. The following description is based on material from these topmost beds exposed at the Mzamba Cliff, collected by us and the late Prof. T. Gevers, respectively.

SAM-7043 is part of a concretion with a complete specimen of *Hauericeras* on the one side (Klinger & Kennedy 1980, fig. 5B), and a large body chamber and part of a phragmocone of *B. sulcatus* on the other side (Fig. 64A). The phragmocone fragment is identical to the lectotype, and we have no doubts in identifying *B. sulcatus* from this bed. Another phragmocone fragment from the same concretion, SAM-7043a shows the transition from the smooth to the laterally ribbed stage at a whorl height of 7.5 mm.

Ornament in the rest of the material varies considerably—from extremely robust, circumperipheral ribbing to virtually smooth. Ornament associated with typical *B. sulcatus* is shown in PCP5684 (Fig. 64E-G), PCP5695 (Fig. 64B-D) and PCP5684 (Fig. 64L-N), consisting of almost circumperipheral ribbing; ribs strongest on the dorsal half of the flanks, and, in sweeping forwards over the ventral half of the flanks, bifurcate or occur with intercalatories, forming distinct chevrons and loops over the venter (Fig. 68D). Dorsally the ribs weaken and curve broadly forward.

On the body chamber, as shown in SAM-7043 (Fig. 64A), ornament seems to weaken, especially on the ventral half of the flanks. Lateral ornament consists of two to three crescentic ribs per whorl height.

Other specimens have less prominent ornament, e.g. PCP8656 (Figs 64K, 65G-H), and only the upper half of the crescentic lateral ribs is visible and less prominent than in the above-mentioned specimens. D1663 (Fig. 76D-E), a body chamber fragment, also has very weak ribbing.

In the last group, e.g. PCP8361 (Fig. 65D-F) and PCP8653 (Fig. 65A-C), ornament is very faint. PCP8153b (Fig. 65I-K) is a body chamber fragment with part of the last septum preserved. Here, lateral ornament is practically absent and only visible under very oblique, low lighting.

Transvaal Museum, Van Hoepen collection. Van Hoepen (1921: 18, pl. 3 (figs 7-8)) described and figured as *B. sulcatus* part of a collection of 22 specimens. Unfortunately, we do not know exactly where in the Mzamba Cliff these specimens were collected. Judging by the preservation, we presume them to be

Fig. 73 (see facing page). *Baculites sulcatus* Bailey, 1855. ?Late forms. A-C. MRC 23. D. MRC 22. E. MRC 34. F-H. MRC 28. I. MRC 14. J. MRC 30. K. MRC 4. L. MRC 19. M. MRC 39. All from excavations for new car park at Wild Coast Casino, Pondoland, Mzamba Formation, Campanian. All $\times 2$.

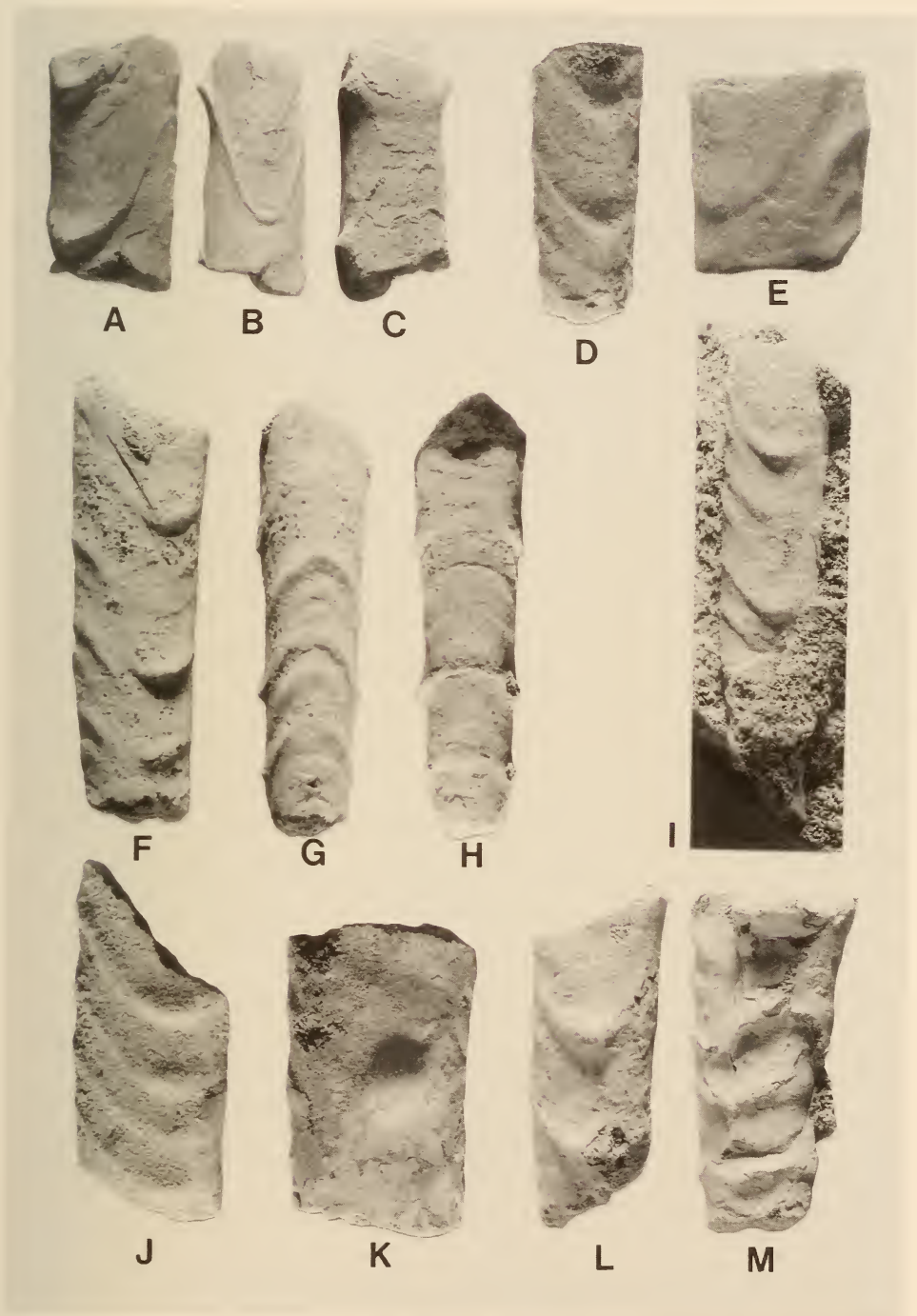


Fig. 73

from below the topmost beds with typical *B. sulcatus*, but also well above the basal beds with *B. capensis*. These specimens differ from typical *B. sulcatus* mainly in that the lateral ribs form a more or less distinct tubercle on the dorsal half of the flanks. In addition, in some of these specimens the whorl section appears to be more elliptical, with the venter as wide as the dorsum and with parallel flanks, reminiscent of *B. capensis* rather than ovoid as in typical *B. sulcatus*.

However, as in typical *B. sulcatus* described above, strength and presence of ornament is extremely variable. TM 540a (Fig. 66J-L) and TM 540d (Fig. 66O-P) have extremely strong ornament; that of TM 540g (Fig. 66A-B) is much weaker, whereas TM 540e, TM 548a (Fig. 66G-I) and TM 548e (Fig. 67C-D) are all practically smooth, save for ventral ribbing. TM 548c (Fig. 67E-G) and TM 548d (Fig. 67H-J) are completely smooth. TM 548d (Fig. 67H-J) and TM 548a (Fig. 66G-I) have parts of the aperture preserved. This consists of a prominent dorsal rostrum, raised by a slight step, a very deep lateral sinus, and a very prominent and long, spoon-shaped ventral rostrum. Part of another aperture is preserved in TM 548b. These are all microconchs. TM 540b (Fig. 66M-O), a body chamber, is a macroconch.

The suture lines of several specimens are exposed, e.g. Figs 68E, 69A-C, 70A-C. These show some variation, but the saddles and lobes are distinctly more incised and complex than those of *B. capensis*; in some, the bases of the saddles and lobes are slightly constricted, resulting in a subtriangular shape. The suture of one of the specimens, TM 540m (Fig. 70C), has rather narrow saddles and resembles the suture of *B. bailyi*—as figured by Woods (1906, pl. 44 (fig. 5)) and as mentioned above (p. 41).

Material from excavations at the Wild Coast Casino. Excavations for a new car park at the Wild Coast Casino, north of the Mzamba River estuary, yielded—amongst others—numerous baculitids best referable to *B. sulcatus*. Again, ornament is quite variable, but in the majority of specimens consists of distinct, widely spaced, crescentic ribs. These are strongest on the upper part of the flanks, decrease in strength and width ventrally, and often cross the venter as distinct lirae. In addition to these latter, intercalatory ribs or lirae may cross the venter, some branching near the venter, forming distinct looped chevrons over the venter (Figs 72-75, 76A-C).

In a few specimens, e.g. MRC 39 (Fig. 73), lateral ornament is as strong as in typical *B. sulcatus*. In another group of about five specimens, lateral ornament consists of obliquely elongated tubercles and ventral ribs, e.g. MRC 12 (Fig. 75A-C), MRC 9, and MRC 4 (Fig. 73K). In others, e.g. MRC 24 (Fig. 72A), MRC 6 (Fig. 72B), MRC 20 (Fig. 74A) and MRC 16 (Fig. 74F), lateral ornament consists of auricular, dorsolateral tubercles, projected ventrally into ribs of variable strength. In a few specimens, e.g. MRC 35 (Fig. 74G), ornament is completely absent.

Fig. 74 (see facing page). *Baculites sulcatus* Baily, 1855. ?Late form. A. MRC 20. B. MRC 25. C. MRC 1a. D. MRC 13. E. MRC 38. F. MRC 16. G. MRC 35. All from excavations for new car park at Wild Coast Casino, Pondoland, Mzamba Formation, Campanian. All $\times 2$, except C $\times 1$.

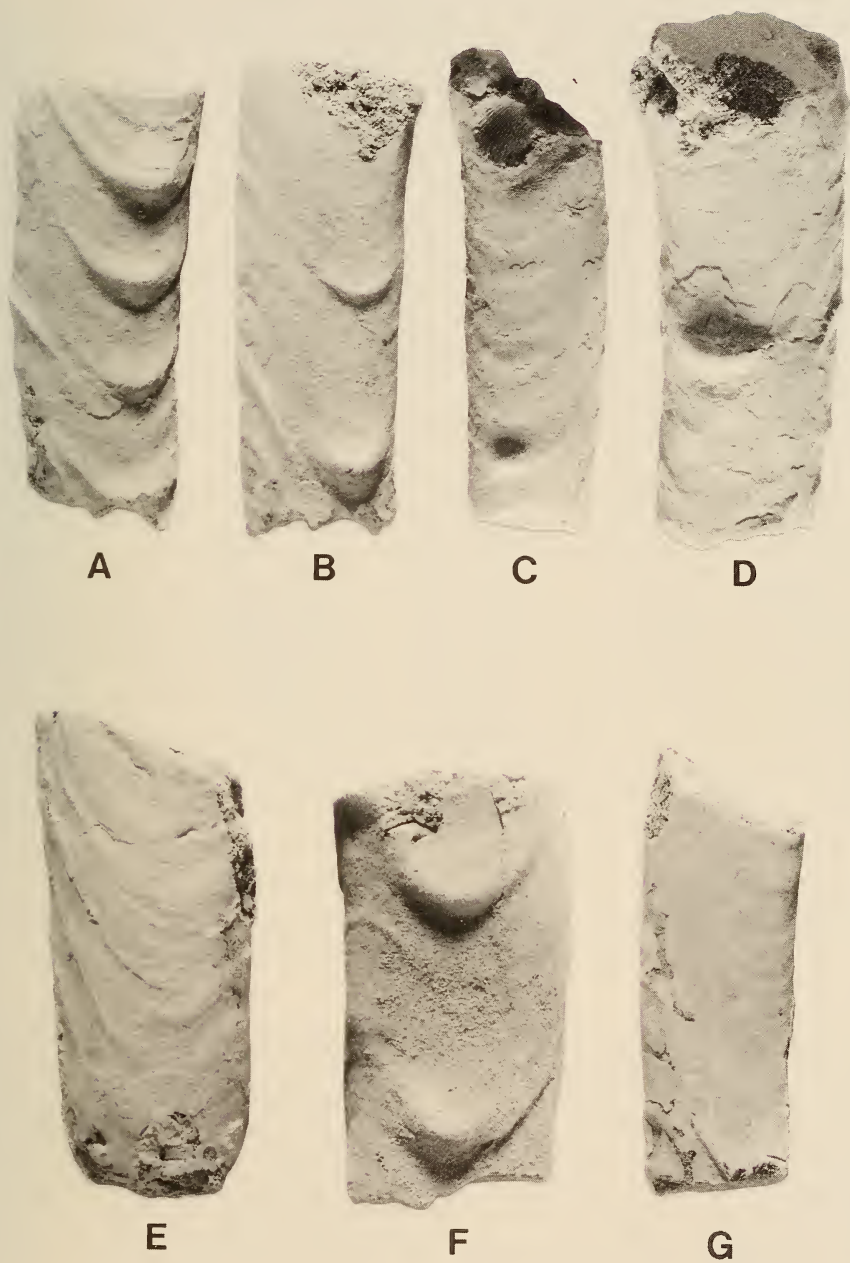


Fig. 74



Fig. 75. *Baculites sulcatus* Baily, 1855. ?Late form. A-C. MRC 12. D. MRC 8, body chamber specimen with aperture. Note distinct curvature of latter. Both from excavations for new car park at Wild Coast Casino, Pondoland, Mzamba Formation, Campanian. All $\times 1$.

Two nearly complete apertures are preserved: MRC 1 (Fig. 76A-C) and MRC 2 at maximum whorl heights of 20 mm and 24 mm, respectively. Most of the specimens show a slight to pronounced curvature on the body chamber, e.g. MRC 32, 33, 8 (Fig. 75D), MRC 24 (Fig. 72A), MRC 25 (Fig. 74B), MRC 2, MRC 13, MRC 20 and MRC 1 (Fig. 76A-C). At first we thought that this was due to diagenetic deformation, but it seems to be a primary feature. In others, however, e.g. MRC 12 (Fig. 75A-C), the body chamber is perfectly straight.

For descriptive purposes, the specimens in the Transvaal Museum may be regarded as early forms of *B. sulcatus*; those from the top of Mzamba cliff as typical forms, and those from the Casino site as ?late *B. sulcatus*.

The suture lines and whorl sections of the latter are shown in Figure 77.

Discussion

Klinger & Kennedy (1977: 76) mentioned that *B. sulcatus* was a relatively rare and poorly understood species. So far it is only definitely known from the Campanian of the Mzamba Formation in Pondoland and from borehole material in Richards Bay, Zululand. As yet, we have not found typical *B. sulcatus* in outcrop in Zululand. Reports of *B. sulcatus* from Zululand (Mkweyane (Umkwelane Hill)) by Spath (1921: 260) are incorrect; these are smooth forms of *B. capensis*. Records of *B. sulcatus* from Madagascar (Collignon 1931: 36, pl. 5 (figs 3-5, 13), pl. 9 (fig. 15)) are also wrong. These Madagascan specimens are of late Coniacian age and probably variants of *B. besairiei* (= *B. yokoyamai*).

We (Klinger & Kennedy 1975: 280) initially thought that *B. vanhoepeii* Venzo, best known from Zululand, was a synonym of *B. sulcatus*. Indeed,

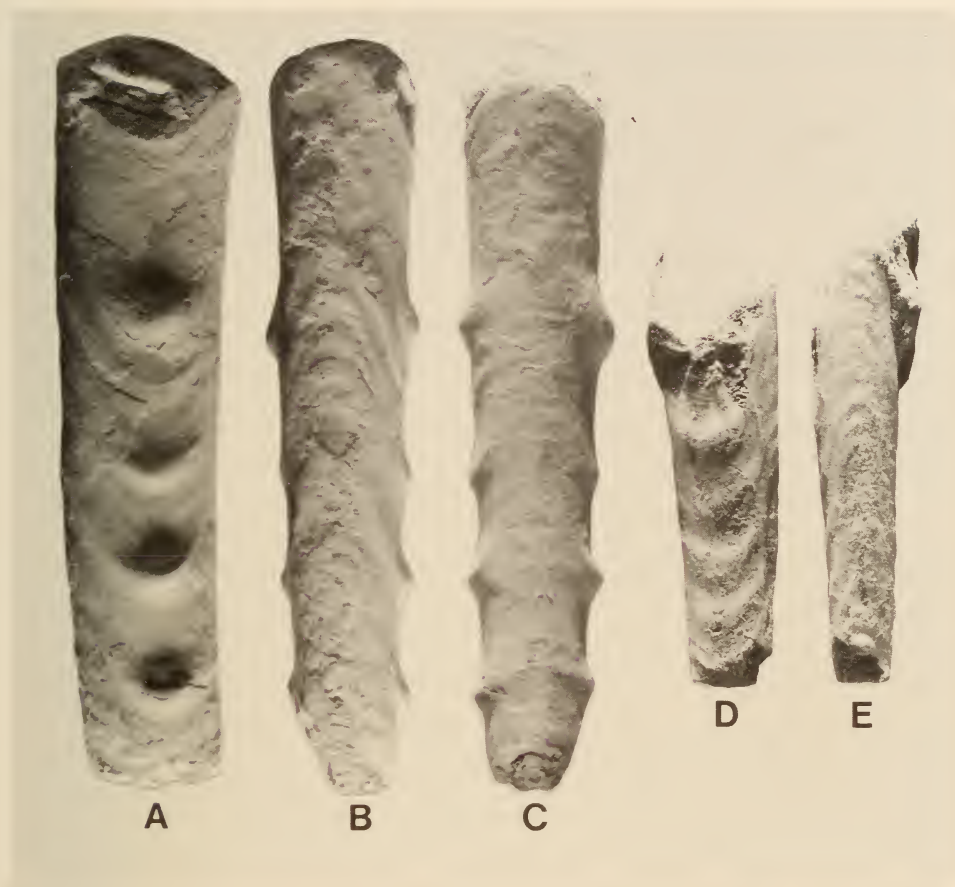


Fig. 76. *Baculites sulcatus* Baily, 1855. A-C. ?Late form. MRC 1, from excavations for car park at Wild Coast Casino, Pondoland, Mzamba Formation, Campanian. D-E. NMBD1663, ex Van Hoepen collection. Typical form from an unrecorded horizon at locality 1, Pondoland, Mzamba Formation, Campanian. Both $\times 1$.

Venzo (1936: 116 [58]) included the specimens described by Van Hoepen (1921: 18, pl. 3 (figs 7-8)) as *B. sulcatus* in the synonymy of *B. vanhoepeni*. Part of the problem in distinguishing between these two species lies in the disparate sizes. Almost all our specimens of *B. sulcatus* are small whereas nearly all our specimens of *B. vanhoepeni* are large. Very few specimens of both species are of equal size for comparison. Small specimens of *B. vanhoepeni*, e.g. Figure 109H, show lateral ornament comparable to that of typical forms of *B. sulcatus*, but none shows as strong ventral or dorsal ribbing as in typical *B. sulcatus*. Adult forms are easily distinguished: *B. vanhoepeni* has typical widely spaced, auricular, lateral tubercles and grows to much larger size than any known *B. sulcatus*. Lateral ornament in typical *B. vanhoepeni* is very similar to that of ?late *B. sulcatus*, but again, none of these late forms of

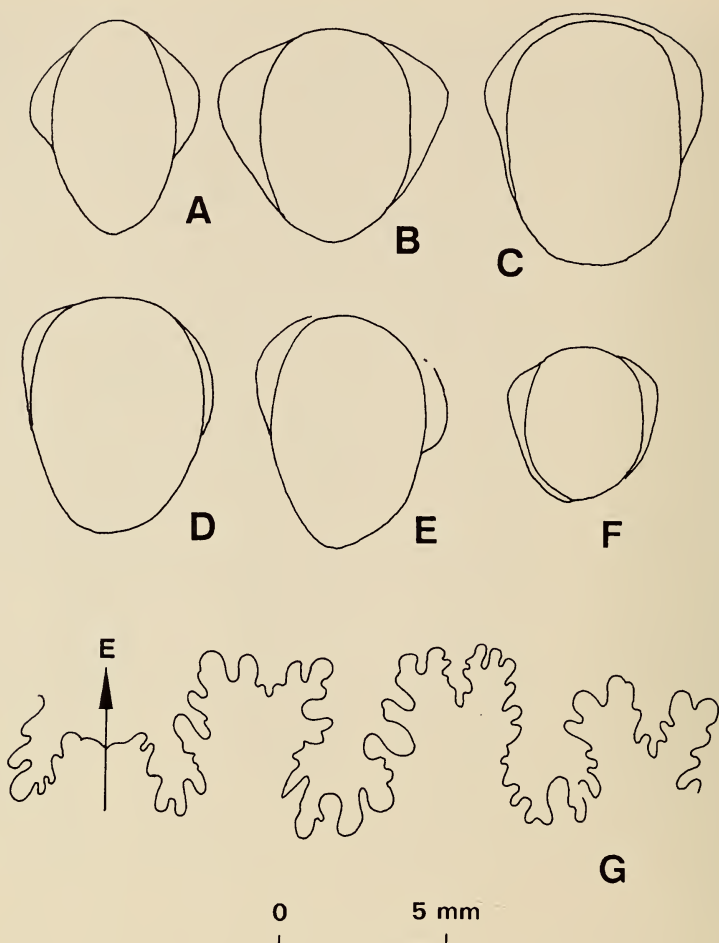


Fig. 77. *Baculites sulcatus* Baily, 1855. ?Late form. Whorl sections and suture line. A-B. MRC 7. C. MRC 6. D. MRC 3. E. MRC 21. F. MRC 23. G. MRC 20. Venter in whorl sections pointing downward. Scale bar for size.

B. sulcatus grows to as large a size as *B. vanhoepeni*, nor is ornament ever as prominent. Also, the two species appear to differ in age: *B. sulcatus* appears restricted to the Lower Campanian, whereas *B. vanhoepeni* is a typical Middle or even partly Upper Campanian species, occurring in association with *Australiella* and *Menabites*.

The origins of *B. sulcatus* are not quite clear. The early forms of *B. sulcatus*, with distinct lateral nodes and elliptical whorl section, are very reminiscent of *B. capensis*. The occurrence of the latter in the basal beds of the Mzamba Formation would support the derivation of *B. sulcatus* from *B. capensis*. It is possible that the transition from *B. capensis* to *B. sulcatus* took place via some of the forms described from the Lower Campanian of

Madagascar by Collignon (1969)—as *B. cf. tanakae* (Collignon 1969: 23, pl. 521 (fig. 2055)) or *B. sparsinodosus* Collignon (Collignon 1969: 23, pl. 521 (figs 2056–8 only)), with crescentic dorsolateral tubercles.

Looking at typical forms of *B. sulcatus*, however, especially the weakly ornamented forms, it would alternatively seem possible to derive the former from late forms of *B. bailyi*. Some specimens of *B. bailyi* from the basal beds of the Mzamba Formation, e.g. SAM-PCP8729 (Fig. 67O–Q), look remarkably like weakly ornamented *B. sulcatus*.

The specimens of ?late *B. sulcatus* from the Casino excavations bear a striking resemblance to an Upper Santonian baculitid fauna recently described from the U.S. Gulf Coast region by Kennedy & Cobban (1991*b*) as *B. capensis* and *Boehmoceras arculus*. Kennedy & Cobban used the name *B. capensis* (1991*b*: 182, figs 6: 4, 8; 1–8; 10: 7–10, 12–14; 12: 2.5) for straight baculites with dorsolateral nodes, and *Boehmoceras arculus* (1991*b*: 182, figs 6: 2, 8; 8: 9–15, 18–22; 9: 1–2, 11–52; 10: 20–21, 24–26; 12: 3) (a senior synonym of *Boehmoceras loescheri* Riedel, 1931) for predominantly curved specimens with distinct, crescentic to auricular lateral bullae that extend across the dorsolateral half to two thirds of the flanks.

As far as lateral ornament is concerned, the Pondoland specimens are indistinguishable from the Gulf Coast material. MRC 1 (Fig. 76A–C) or MRC 8 (Fig. 75D) are indistinguishable from specimens assigned to *B. arculus* by Kennedy & Cobban (1991*b*, fig. 9: 50–52 or fig. 9: 46), but none of our specimens has as distinct curvature as the Gulf Coast material to merit assignation to the genus *Boehmoceras*.

It is obvious that in both assemblages we are dealing with a baculitid population morphologically transitional between *Baculites* and *Boehmoceras*, with both having their origins in *B. capensis*. As shown above (p. 71), some specimens of *B. capensis* have slightly curved body chambers. In the majority of the Pondoland specimens, ornament is of the *Boehmoceras arculus* or *Baculites sulcatus* type, but curvature is restricted to the body chamber, as in *B. capensis*, and they still belong to *Baculites* s.s. In the Gulf Coast material, lateral ornament is the same, but the curvature is more distinct and already occurs on the phragmocone, and they are referable to *Boehmoceras*. In both populations, more or less straight specimens with *B. capensis*-like ornament occur associated with the curved specimens, indicating an origin in the latter species. It is tempting to link *B. capensis* to the Gulf Coast *Boehmoceras* fauna via the Pondoland specimens but, lacking a precise date for the latter assemblage, this is not advisable at present. Affinities of ?late *B. sulcatus* with typical forms of *B. sulcatus*, rather suggests that the Pondoland and Gulf Coast faunas have a common origin in the Upper Santonian in *B. capensis*, and subsequently acquired similar ornament, but developed in parallel. The Gulf Coast fauna became progressively more curved and gave rise to true *Boehmoceras*, whereas the Pondoland fauna remained in the strict *Baculites* lineage.

Baculites increscens Collignon (1970: 3, pl. 607 (figs 2266–2268)) from the Middle Campanian of Zululand and Madagascar resembles ?late *B. sulcatus*, but lateral ornament in the former is more prominent, and transitional to the prominent auricular *B. vanhoepeni* type.



Fig. 78. A-B. *Baculites bailyi* Woods, 1906. A. SAM-PCZ8358, concretion with *B. bailyi* and *Premuniericeras* from locality 98, Zululand, St Lucia Formation, Santonian II. B. SAM-PCZ7214, concretion crammed with juvenile *B. bailyi* from locality 73, Zululand, St Lucia Formation, Coniacian IV or V. C. *B. sulcatus* Baily, 1855. SAM-PCP8361, concretion from locality 1, Pondoland, Mzamba Formation, Campanian I. All $\times 1$.

Strongly ornamented forms of typical *B. sulcatus* bear superficial resemblance to *Trachybaculites columna* (Morton, 1834) (see Cobban & Kennedy 1992c for a recent review). *Trachybaculites columna*, however, is a Maastrichtian species known from the Prairie Bluff Chalk of Alabama, the Corsicana Marl of the Navarro Group of Texas, Trail City Member of the Fox Hills Formation in South Dakota, and also from the Ganzas Formation of the San Joaquin Valley, California (Matsumoto 1959: 163). Ribbing seems to be more uniform, and stronger on the dorsum and venter than in *B. sulcatus*. Also, the suture is distinctly simple compared to that of *B. sulcatus*.

Baculites furcillatus (Blanckenhorn, 1905, pl. 6 (fig. 2)) (herein Fig. 67E-F) has ornament similar to that of some *B. sulcatus*. This is a rare species in the Maastrichtian of Israel, and more material is needed for definite comment. According to Picard (1929: 441), *B. furcillatus* 'is only a strongly ribbed form of *B. palestinensis*'. Ribbing in *B. furcillatus* is stronger over the venter and dorsum than in *B. sulcatus*, and thus seems closer to *T. columna*.

Baculites thomi Reeside (1927b: 13, pl. 12 (figs 9-14)) from the Elk Basin Sandstone member of the Telegraph Creek Formation of the U.S. Western Interior, is superficially similar to some typical *B. sulcatus* in the strong, circumperipheral ribbing. However, a recent review of the species by Cobban & Kennedy (1991a: C1-C8, pls 1-2) showed that Reeside's original figures of the holotype were retouched. According to Cobban & Kennedy (1991a), *B. thomi* first appears in the Upper Santonian, where it reaches its peak, and persists into the Lower Campanian. Ornament in *B. thomi* is far more regular than in *B. sulcatus*, with very regular ventral corrugations developing in typical forms. Also, the suture line (Cobban & Kennedy 1991a, fig. 2A-B) is less complex.

Some representatives of two baculitid species from the Coniacian of the U.S. Western Interior are very similar to *B. sulcatus*. These are *B. sweetgrassensis* Cobban, 1951 (see Kennedy & Cobban 1991a: 70, pl. 14 (figs 24-25, 29-34, 38-42)) and *B. codyensis* Reeside (see Kennedy & Cobban 1991a: 72, pl. 15 (figs 1-30), pl. 16 (figs 1-13), pl. 17 (figs 1-8), text-fig. 25F).

Baculites sweetgrassensis is a Middle Coniacian species, and, in typical forms, has widely spaced, crescentic bullae that are projected ventrally into sharp, forwardly direct ribs. Superficially some of these (e.g. Kennedy & Cobban 1991a, pl. 14 (fig. 40-41)) resemble early forms of *B. sulcatus*; others, (e.g. Kennedy & Cobban 1991a, pl. 14 (figs 30, 38)) resemble ?late *B. sulcatus*.

Baculites codyensis first appears in the Middle Coniacian, and ranges up to the Middle Santonian. Typical forms have regular, concave, concentric ribs, and these, together with the age difference clearly separate *B. codyensis* from *B. sulcatus*. Some of the more coarsely ornamented forms of *B. codyensis* (see e.g. Kennedy & Cobban 1991a, pl. 16 (fig. 12)) resemble ?late forms of *B. sulcatus*, but again, this is mere homoeomorphy.

Some specimens of *B. ovatus* Say, recently figured by Kennedy & Cobban (1993c, fig. 15. 9-12), are remarkably similar to our ?late *B. sulcatus*, but *B. ovatus* is a younger species, and typically has weaker ornament than *B. sulcatus*.

Baculites oberholzeri Böhm (1909: 52, pl. 1 (fig. 9a-b)), imprecisely dated from the Senonian of Switzerland, appears to have similar lateral ornament, but this species is based on a crushed fragment, about 11 mm long, and is best regarded as a *nomen dubium*.

Some specimens described and figured by Birkelund (1965: 58, pl. 8 (fig. 1), pl. 9 (figs 1–3), pl. 10 (fig. 1), pl. 11 (figs 1–2), pl. 12 (figs 1–2), pl. 13 (figs 1–2), pl. 14 (fig. 1), text-figs 47–52) as *Baculites obtusus* Meek from the Lower Campanian of West Greenland resemble *B. sulcatus*, but none of the specimens develops as strong ornament as typical representatives of the latter.

Typical forms of *B. sulcatus* are also nearly identical with some *B. leopoliensis* Nowak (see e.g. Kennedy 1986e, pl. 2 (figs 11–12)); this, however, is an Upper Campanian species, and typical forms have more regular, thin, crescentic ribs.

Occurrence

To date, *B. sulcatus* has only been recorded from the Lower Campanian of Pondoland and in subsurface deposits at Richards Bay, Zululand.

Baculites increscens Collignon, 1970

Figs 79A–L, N–O, 80A–B, 82

- 1970 *Baculites increscens* Collignon, p. 3, pl. 607 (figs 2266–2268), p. 5, pl. 608 (fig. 2269).
 1970 *Baculites tanakaeformis* Collignon, p. 2, pl. 607 (figs 2263–2265).
 1970 *Baculites androtsyensis* Collignon, p. 5, pl. 608 (figs 2270–2272).
 1970 *Baculites mamillatus* Collignon, p. 7, pl. 609 (figs 2273–2274).

Type

Holotype, by original designation, the specimen figured by Collignon (1970, pl. 607 (fig. 2266)) from the Middle Campanian, Zone of *Pachydiscus grossouvrei*, subzone of *Eupachydiscus lamberti*, gisement 177, Coupe d'Ankilizato (Belo sur Tsiribihina), Madagascar, housed in the collections of the Institut des Sciences de la Terre, Université de Dijon, GD 12266, here refigured as Figure 82.

Material

SAM-PCZ11986–11996, all from locality 102, Zululand, St Lucia Formation, Campanian II.

Description

All of our material is fragmentary, but the specimens range in size from juveniles to large body chamber sections, covering all the growth stages.

PCZ11992 (Fig. 79I–J) is a juvenile and shows distinct crescentic, dorsolateral nodes. PCZ11995 at similar whorl height has less conspicuous nodes but shows a distinct trigonal whorl section. PCZ11996, at whorl height

Fig. 79 (see facing page). A–L, N–O. *Baculites increscens* Collignon, 1970. A–D. SAM-PCZ11988. E. SAM-PCZ11991. F–H. SAM-PCZ11997. I–J. SAM-PCZ11992. K–L. SAM-PCZ11987. N–O. SAM-PCZ11993, all from locality 103, Zululand, St Lucia Formation, Campanian ?II. M. *Baculites vanhoepeni* Venzo, 1936. SAM-PCZ11998 from locality 110, Zululand, St Lucia Formation, Campanian II or III. All $\times 1$.

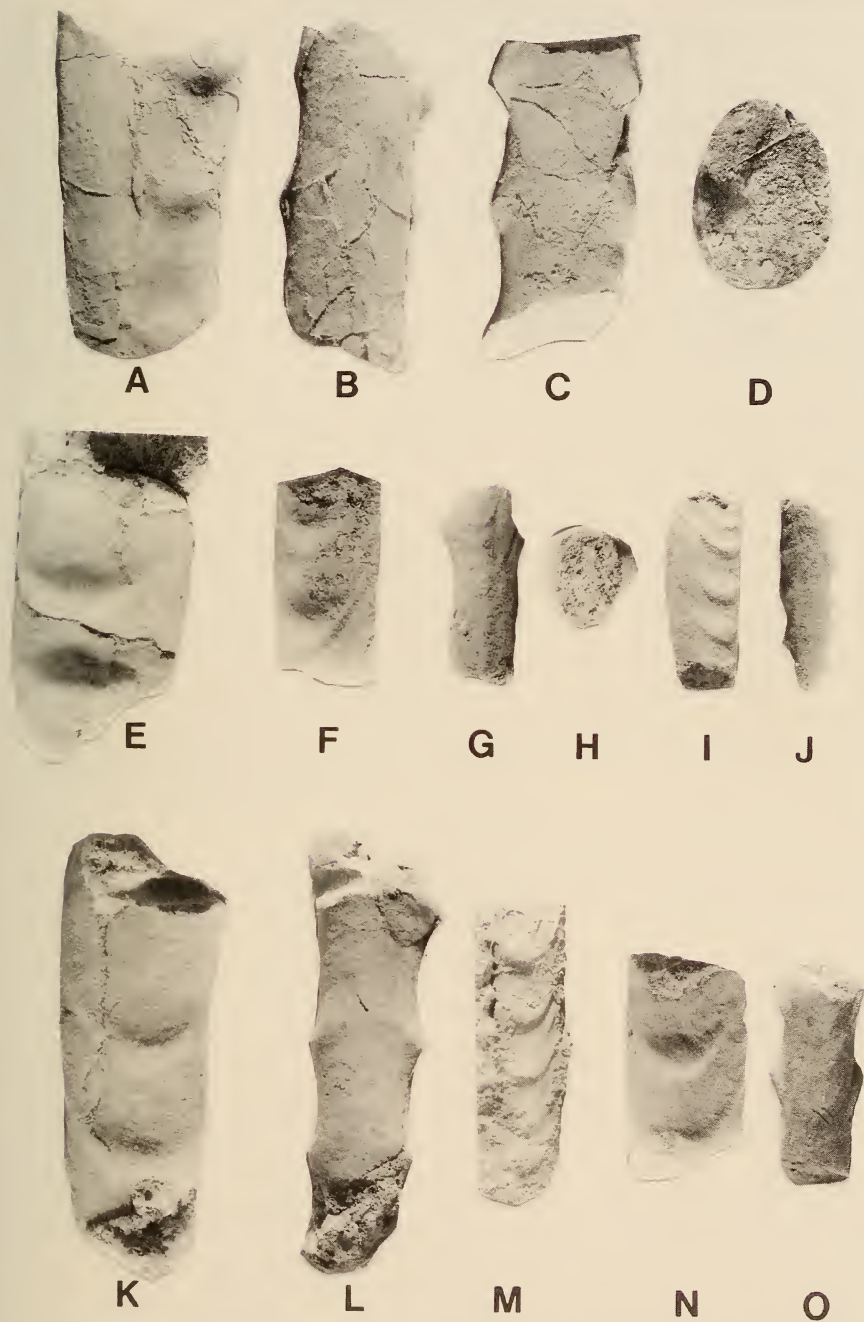


Fig. 79

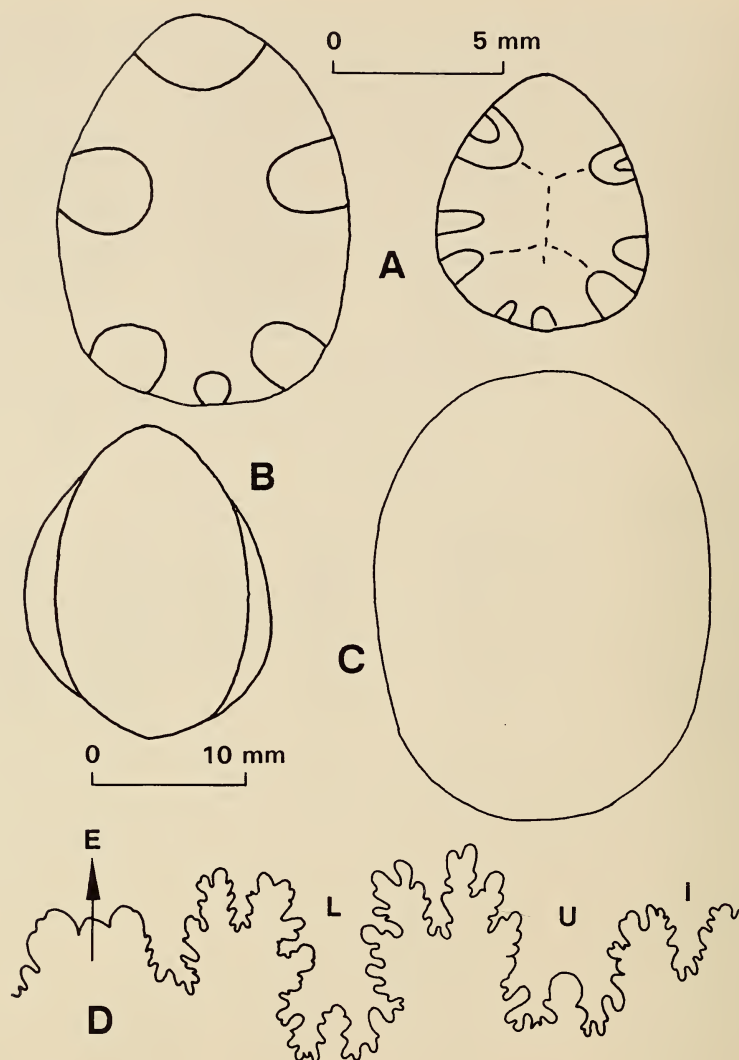


Fig. 80. Whorl sections and suture lines. A-B. *Baculites increscens* Collignon, 1970. A. SAM-PCZ11995. B. SAM-PCZ11986. C-D. *Baculites duharti* Hünicken, 1965. C. SAM-PCZ7685. D. SAM-PCZ7685. Venter in whorl section pointing upward. Scale bar for size.

12 mm, shows a similar rounded, trigonal whorl section. PCZ11993 (Fig. 79N-O) and PCZ11986 show typical phragmocone ornament consisting of prominent, dorsolaterally situated auricular nodes, projected ventrally into thin lirae that cross the venter, accompanied by intercalated lirae. Slightly more than two nodes occur per whorl height. The whorl section is compressed ovoid (Fig. 80A-C) with the dorsum flat to slightly rounded, and the venter narrowly rounded. PCZ11990 is a fragment, and has large, rounded, instead of crescentic dorsolateral nodes.

UPPER CAMPANIAN			
MIDDLE CAMPANIAN	Zone of <i>Delawarella subdelawarensis</i> and <i>Australiella australis</i>		<i>B. cf. taylorensis</i> Adkins (183) <i>B. ankilizatensis</i> sp. nov. (153-159) <i>B. rectangulatus</i> sp. nov. (156-157)
	Zone of <i>Pachydiscus grossouvrei</i>	Sub-zone of <i>Pachydiscus bassae</i>	<i>B. ankilizatensis</i> sp. nov. (first: 153-159) <i>B. leopoliensis</i> Nowak (177-156)
		Sub-zone of <i>Eupachydiscus lamberti</i>	<i>B. coagmentatus</i> sp. nov. (177-156) <i>B. increscens</i> (last: 177) <i>B. androtsyensis</i> sp. nov. (180 & 327-328-329) <i>B. mamillatus</i> sp. nov. (181-326) <i>B. increscens</i> (first: 180-181) <i>B. tanakaeformis</i> sp. nov. (326-327 & 180-181)
	Top of Lower Campanian: Sub-zone of <i>Termiericeras lenticulare</i>		
LOWER CAMPANIAN			

Fig. 81. Biostratigraphic zonation of the Middle Campanian and distribution of *Baculites* spp. at Menabe, Madagascar after Collignon (1969).

PCZ11991 (Fig. 79E), PCZ11988 (Fig. 79A-C) and PCZ11989 are body chamber fragments. Lateral ornament varies from closely spaced crescentic ribs, to low and rounded nodes. Some fragments appear to have been smooth.

Discussion

Baculites increscens is but one of several baculitids described by Collignon (1970) from the Middle Campanian of Madagascar. Our material fits the description of *B. increscens* best, but several features ascribed to the other Madagascar species are also present, and it is necessary to comment on the latter.

According to Collignon's (1970) stratigraphy of the Middle Campanian of Menabe, Madagascar (Fig. 81) the majority of *Baculites* species occur in the lower part of the substage, in the Zone of *Pachydiscus grossouvrei*, Subzone of *Eupachydiscus lamberti*. These include *B. coagmentatus* Collignon (1970: 7,

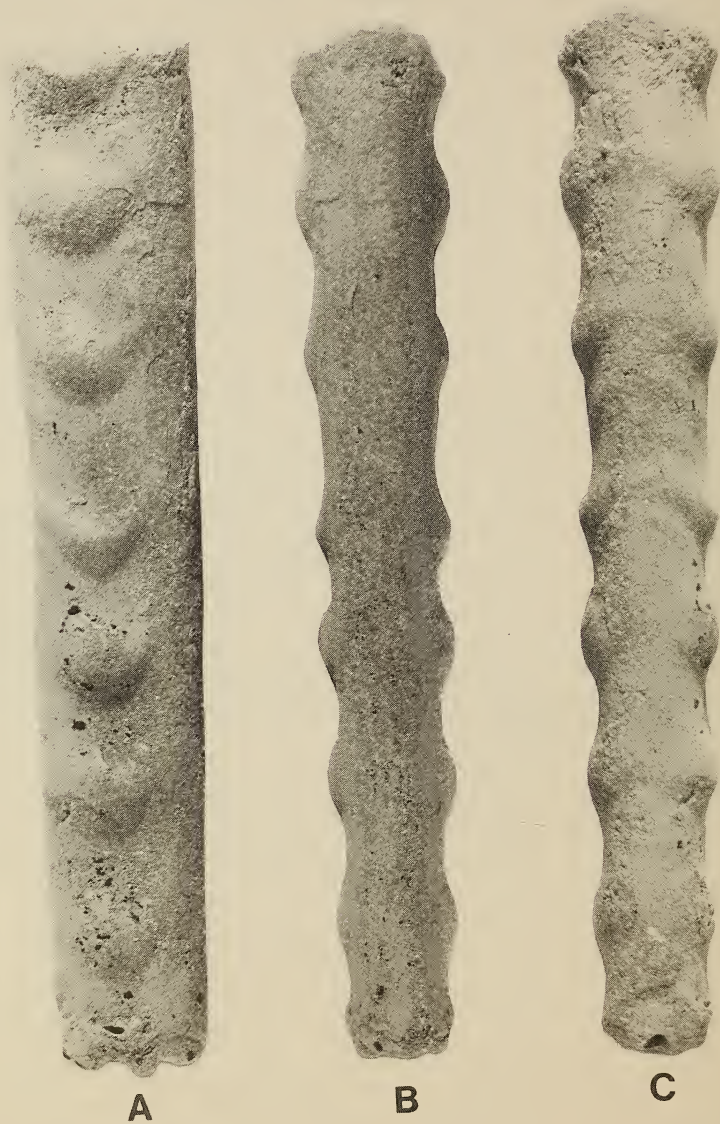


Fig. 82. *Baculites increescens* Collignon, 1969. Plaster cast of the holotype, GD12266, the original of Collignon (1970, pl. 607 (fig. 2266)) from the Middle Campanian of gisement 177, Coupe d'Ankilizato (Belo sur Tsiribihina), Madagascar. $\times 1$.

pl. 609 (figs 2275–2276)) (herein Fig. 88); *B. increscens* Collignon (1970: 3, pl. 607 (figs 2266–2268)) (herein Fig. 82); *B. androtsyensis* Collignon (1970: 5, pl. 608 (figs 2270–2272)) (herein Fig. 83), *B. mamillatus* Collignon (1970: 7, pl. 609 (figs 2273–2274)) (herein Fig. 84A–C) and *B. tanakaeformis* Collignon (1970: 2, pl. 607 (figs 2263–2265)) (herein Fig. 84D–F).

The order of their listing below suggests that this is the order of their occurrence, but this is not strictly so. If they are arranged according to their occurrence at the different localities or horizons (Collignon's 'gisements'), it is clear that these species are contemporary to a large extent.

'Gisement'

183	<i>Baculites</i> cf. <i>B. taylorensis</i>
153	<i>Baculites ankilizatensis</i> <i>Baculites coagmentatus</i>
156	<i>Baculites rectangulatus</i> <i>Baculites leopoliensis</i>
157	<i>Baculites rectangulatus</i>
159	<i>Baculites ankilizatensis</i>
177	<i>Baculites leopoliensis</i> <i>Baculites coagmentatus</i> <i>Baculites increscens</i>
180	<i>Baculites androtsyensis</i> <i>Baculites increscens</i> <i>Baculites tanakaeformis</i>
181	<i>Baculites mamillatus</i> <i>Baculites increscens</i> <i>Baculites tanakaeformis</i>
329	<i>Baculites androtsyensis</i>
328	<i>Baculites androtsyensis</i>
327	<i>Baculites androtsyensis</i> <i>Baculites tanakaeformis</i>
326	<i>Baculites tanakaeformis</i> <i>Baculites mamillatus</i>

According to Collignon (1970: 2), *B. tanakaeformis* occurs at the base of the Middle Campanian, and *B. androtsyensis* is the oldest of the series of baculitids that dominates the Middle Campanian (Collignon 1970: 5). Both occur together at gisement 327; at gisement 181 they occur together with *B. increscens*; and at 326 and 181 *B. tanakaeformis* occurs with *B. mamillatus*.

On the basis of their co-occurrence, it would seem logical to regard the above-mentioned four species, *B. tanakaeformis*, *B. increscens*, *B. androtsyensis* and *B. mamillatus* as a single, variable species. However, Collignon

based these species on large assemblages—*B. tanakaeformis* (87 specimens), *B. androtsyensis* (50 specimens) and *B. increscens* (50 specimens), and they cannot summarily be dismissed as synonyms.



Fig. 83. *Baculites androtsyensis* Collignon, 1969. Plaster cast of the holotype, GD12270, the original of Collignon (1970, pl. 608 (fig. 2270)), from the Middle Campanian of gisement 329, Coupe Ampolypoly-Antsirasilira-Behamotra (Belo sur Tsiribihina), Madagascar. $\times 1$.

All four species have a subtriangular whorl section in common, with faint indications of longitudinal depressions on either side of the venter, indicating an incipient ventral keel. Lateral ornament varies from strong crescentic to mammiform in *B. increscens*, weaker in *B. androtsyensis* (with more compressed whorl section), distinct mammiform in *B. mamillatus*, conical to obliquely elongated in *B. tanakaeformis*. The suture lines of *B. mamillatus* and *B. androtsyensis* (Figs 85A, C) are very similar.

We do not doubt that these four broad morphological groups can be identified in large collections, and that some morphotypes probably are more common at certain localities than others in Madagascar. However, our Zululand material from locality 102 shows that even though the majority of specimens are identifiable with *B. increscens*, some specimens could be referred to either of the other three species, e.g. PCZ11993 (Fig. 79N-O) and PCZ11986 have a more compressed whorl section as in *B. androtsyensis*; PCZ11988 (Fig. 79A-D) has rounded tubercles as in *B. mamillatus*; those of PCZ11991 (Fig. 79E) are as in *B. tanakaeformis*. Because of this, we doubt if it is justifiable to maintain formal specific names for these different, yet overlapping and co-eval morphotypes and, as first revising authors, we select *Baculites increscens* as the name of this species.

Baculites coagmentatus Collignon (1970: 7, pl. 609 (figs 2275-2276)) (Fig. 88) appears to be slightly younger than most of the baculitids of the group of *B. increscens*, but co-occurs with the last appearance of *B. increscens* at Collignon's locality 177. The whorl section is still subtriangular as in *B. increscens*, but the ornament of *B. coagmentatus* consists essentially of thin, closely spaced, crescentic ribs—a mode of ornament found in some of the Durban specimens of *B. vanhoepeni* to be described below. *Baculites leopoliensis* Collignon (1970: 10, pl. 610 (figs 2277-2278) non Nowak) (herein Fig. 86) has a more ovoid whorl section, but similar lateral ornament as in *B. coagmentatus* and they are probably synonyms. *Baculites leopoliensis* Nowak (1908: 328, pl. 14 (figs 1-5, 10, ?11), text-figs 1-5 on p. 329, ?text-figs 5-10 on p. 331) is a typical Upper Campanian species (see Hancock & Kennedy 1993: 165) and not Lower Maastrichtian as recorded earlier by, for example, Kennedy (1986c: 1013). The ornament consists of lateral ribs that break down into riblets and striae on the venter, whereas intercalated ribs develop over the venter. This style of ornament is quite characteristic and unlike that of the Madagascar material. *Baculites leopoliensis* Collignon non Nowak is here renamed *B. collignoni* nom. nov. *Baculites coagmentatus* and *B. collignoni* have a style of ornament similar to some forms of *B. vanhoepeni* (see e.g. Fig. 111A-C), and these two species can probably be regarded as ?early forms (and junior synonyms?) of *B. vanhoepeni*.

Fig. 84 (see overleaf). A-C. *Baculites mamillatus* Collignon, 1970. Plaster cast of the holotype, GD12273, the original of Collignon (1970, pl. 609 (fig. 2273)) from the Middle Campanian of gisement 181, Coupe d'Ankilizato (Belo sur Tsiribihina), Madagascar. D-F. *Baculites tanakaeformis* Collignon, 1970. Plaster cast of the holotype, GD12263, the original of Collignon (1970, pl. 607 (fig. 2263)) from the Middle Campanian of gisement 326, Coupe Ampolypoly-Antsirasisira-Behamotra (Belo sur Tsiribihina), Madagascar.

Both $\times 1$.

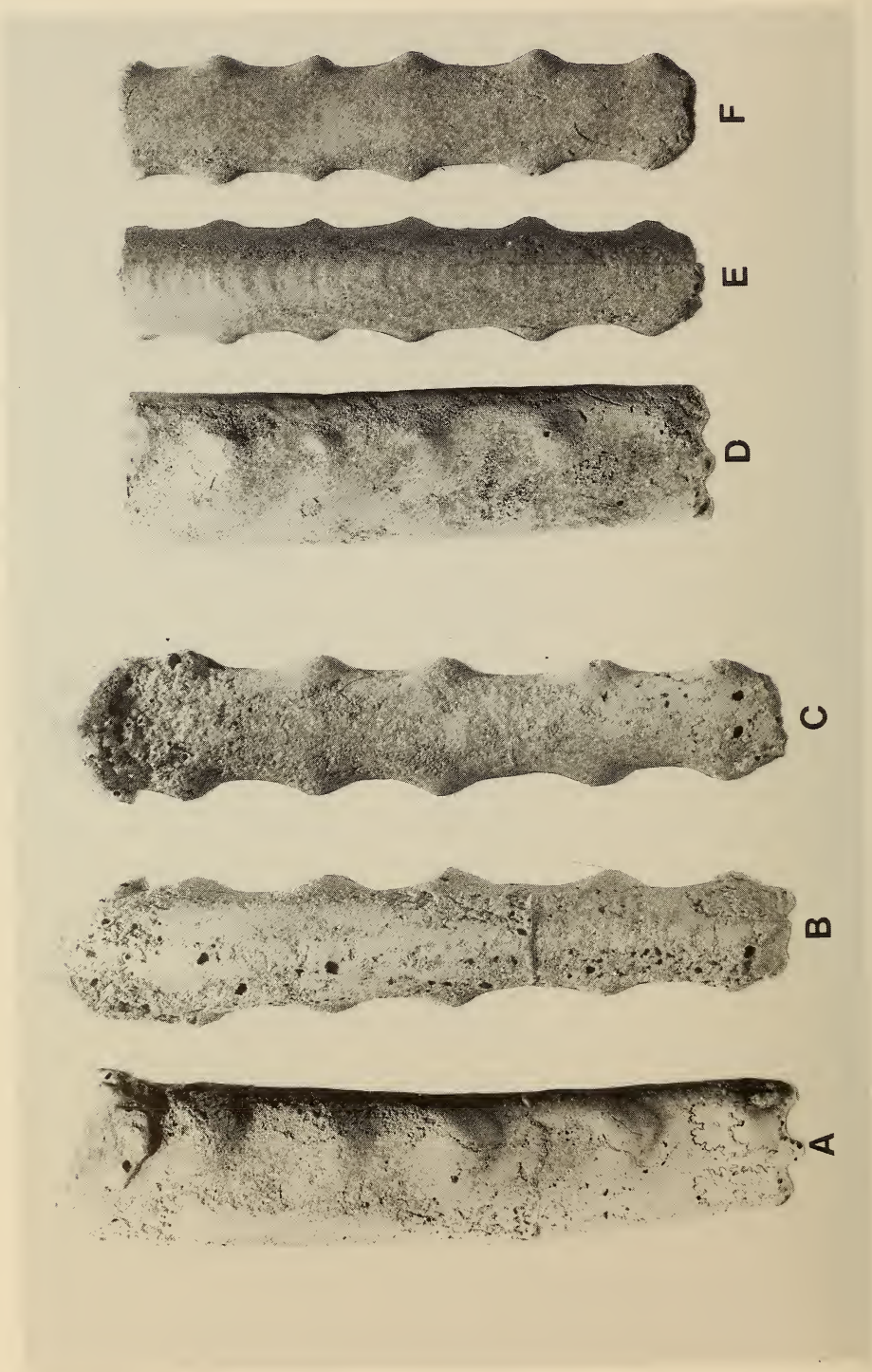


Fig. 84

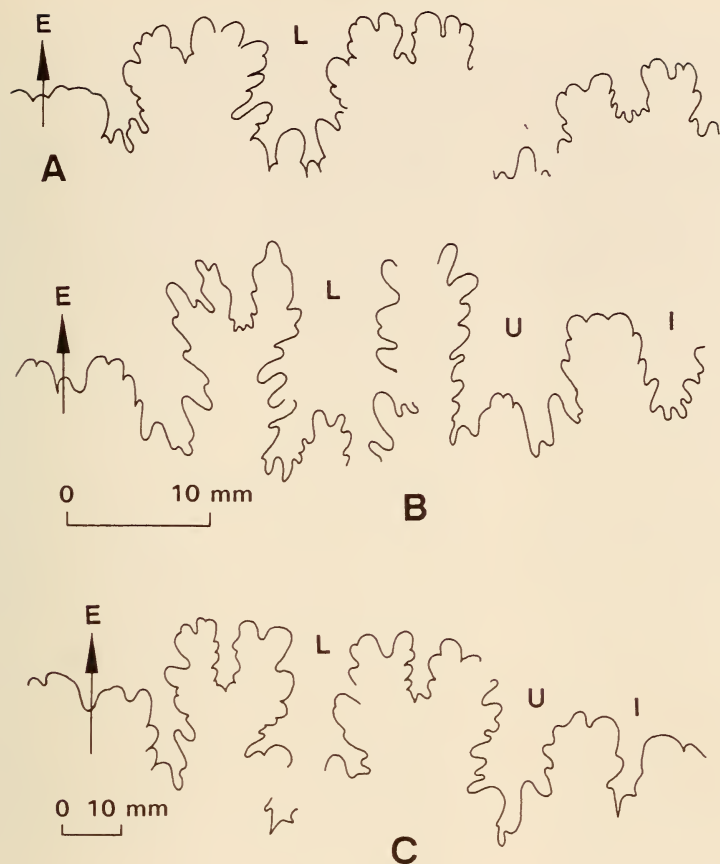


Fig. 85. Suture lines. A. *Baculites mamillatus* Collignon, 1970. GD12273. (see Fig. 84A-C). B. *Baculites ankilizatensis* Collignon, 1970. GD12282 (see Fig. 89). C. *Baculites androtsyensis* Collignon, 1970. GD12270 (see Fig. 83). Scale bars for size.

Baculites rectangulatus Collignon (1970: 12, pl. 611 (figs 2279–2281)) (herein Fig. 87) is a late representative of the group of *B. increscens* as far as ornamentation is concerned. The whorl section, however, is more compressed and subrectangular. *Baculites ankilizatensis* Collignon (1970: 13, pl. 612 (figs 2282–2284)) (herein Fig. 89) is a large baculitid with reduced lateral ornament.

In Zululand, *B. increscens* appears to occupy an intermediate position between *B. sulcatus*, especially the material from the Casino excavations, and *B. vanhoepeni*. Juvenile specimens of *B. increscens* are virtually indistinguishable from ?late *B. sulcatus*. *Baculites increscens* differs from *B. sulcatus* mainly in having stronger lateral ornament in the adult stage, and from *B. vanhoepeni* in being weaker ornamented. To be quite frank, the main reason for separating *B. increscens* in Zululand is probably because of its isolated occurrence at locality 102.



Fig. 86. *Baculites collignoni* nom. nov. Plaster cast of GD12277, the original of *Baculites leopoliensis* non Nowak in Collignon (1970, pl. 610 (fig. 2277)) from gisement 156, Coupe d'Ankilizato (Belo sur Tsiribihina), Madagascar. $\times 1$.



Fig. 87. *Baculites rectangularatus* Collignon, 1970. Plaster cast of the holotype, GD12279, the original of Collignon (1970, pl. 611 (fig. 2279)) from the Middle Campanian of gisement 157 of Coupe d'Ankilizato (Belo sur Tsiribihina), Madagascar. $\times 1$.



Fig. 88. *Baculites coagmentatus* Collignon, 1970. Plaster cast of the holotype, GD12275, the original of Collignon (1970, pl. 609 (fig. 2275)) from the Middle Campanian of gisement 177, Coupe d'Ankilizato (Belo sur Tsiribihina), Madagascar. $\times 1$.



Fig. 89. *Baculites ankilizatensis* Collignon, 1970. Plaster cast of the holotype, GD12282, the original of Collignon (1970, pl. 612 (fig. 2282)) from the Middle Campanian of gisement 153, Coupe d'Ankilizato (Belo sur Tsiribihina), Madagascar. $\times 1$.

Baculites nibelae sp. nov., described below (p. 162) is younger than typical *B. increescens*, lateral ornament is similar, but the whorl section is characteristically wedge-shaped, trigonal, with a flat dorsum and a narrow venter.

Occurrence

Middle Campanian of Zululand and Madagascar.

Baculites vanhoepeni Venzo, 1936

Figs 79M, 91-115

- 1936 *Baculites vagina* Forbes var. *van Hoepeni* Venzo, p. 116 [58], pl. 10 [6] (figs 11-12).
 1973 *Baculites* sp. group of *Baculites capensis* Woods; Kennedy & Klinger, p. 100, pl. 4 (figs 1-5), pl. 5 (fig. 1a-d), pl. 6 (figs 4-5).
 1975 *Baculites sulcatus* (non Baily); Kennedy & Klinger, p. 280.
 ? 1970 *Baculites coagmentatus* Collignon, p. 7, pl. 609 (figs 2275-2276).
 ? 1970 *Baculites leopoliensis* non Nowak, Collignon, p. 10, pl. 610 (figs 2277-2278) (= *B. collignoni* nom. nov.)
 1977 *Baculites vanhoepeni* Venzo; Kennedy & Klinger, p. 73, figs 2G-K, 3A, H-I, 4A-C, 5C.

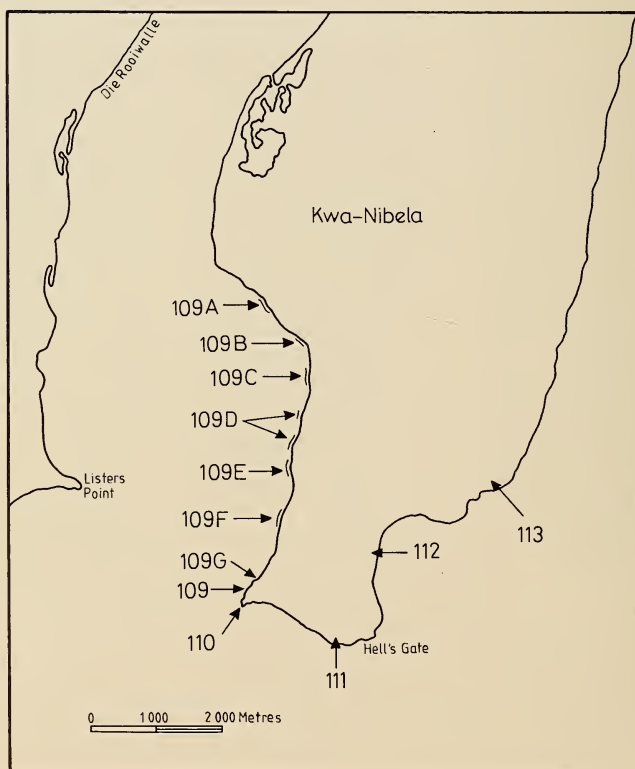


Fig. 90. Localities on Nibela Peninsula referred to in text, but not included in Kennedy & Klinger (1975).

Type

Venzo (1936: 116 [58]) based this species on several specimens. Klinger & Kennedy (1977: 73) designated the larger of the two specimens figured by Venzo (1936, pl. 10 [6] (fig. 11a-b)) from 'False Bay', Zululand, as lectotype. It is housed in the Department of Geological Sciences, University of Bologna, no. 1 GO 243.

Material

We have more than 150 specimens from localities on the Nibela Peninsula (Fig. 90), Zululand, St Lucia Formation, Campanian II-III.

Dimensions

A list of dimensions is given in the appendix.

<i>Max Wb (mm)</i>	<i>MxWb/MxWh</i>	<i>MnWb/MnWh</i>	<i>Ti</i>	<i>Ri</i>
10-14.9	0.71	0.69	5.32	0.81
15-19.9	0.71	0.73	4.7	0.8
20-24.9	0.77	0.76	4.9	1.15
25-27.9	0.77	0.79	3.8	1.28
30-34.9	0.77	0.77	6.2	1
37	0.80	—	—	—

Description

This species is conspicuous by its large size; the largest available specimen (D1302b, Fig. 103) has a whorl height of 55 mm. Unfortunately, the early stages are poorly known—almost all our specimens are large. This is probably due to taphonomic and/or diagenetic factors.

Early stages of growth are shown in PCZ7714 (Fig. 109H). Here the whorl section is more or less ovoid, with a narrow venter. Ornament consists of dorsolaterally situated crescentic ribs which are projected ventrally and aperturally over the venter, numbering about 2.5 per whorl height.

All the characteristic features of the species are shown in PCZ8764 (Fig. 91A-C). The bullae are typically crescentic to auricular, with sharp to rounded lateral crests, and are situated on the dorsal half of the flanks. Ventrally, they are projected acutely forwards and over the venter as thin riblets. In addition, a variable number of intercalatories arises on the ventral half of the flanks, and these also cross the venter with distinct, albeit variable corrugation.

Fig. 91 (*see overleaf*). *Baculites vanhoepeni* Venzo, 1936. A-C. SAM-PCZ8764. D-F. SAM-PCZ7717. G-I. SAM-PCZ7415. J-L. SAM-PCZ7707. M-O. SAM-PCZ7091. Note the irregular occurrence of ventral corrugations. All from locality 110, Zululand, St Lucia Formation, Campanian II-?III. All $\times 1$.

Fig. 92 (*see overleaf*). *Baculites vanhoepeni* Venzo, 1936. A-C. NMBD1467. D. SASZ1911. E-F. NMBD1467a. G-H. SASZ1863e. Note the aperture in D and H. All from locality 110, Zululand, St Lucia Formation, Campanian II-?III. All $\times 1$.

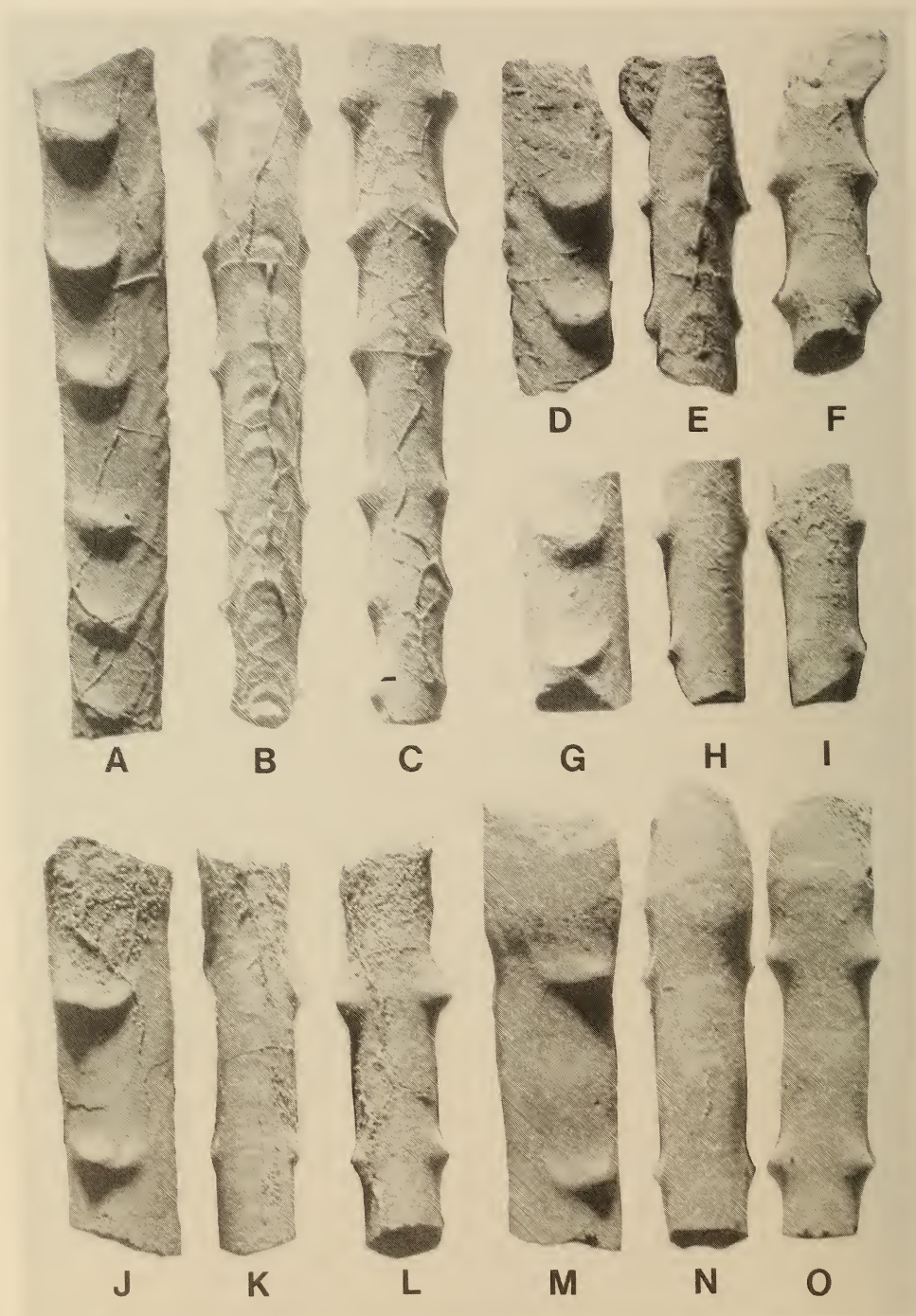


Fig. 91

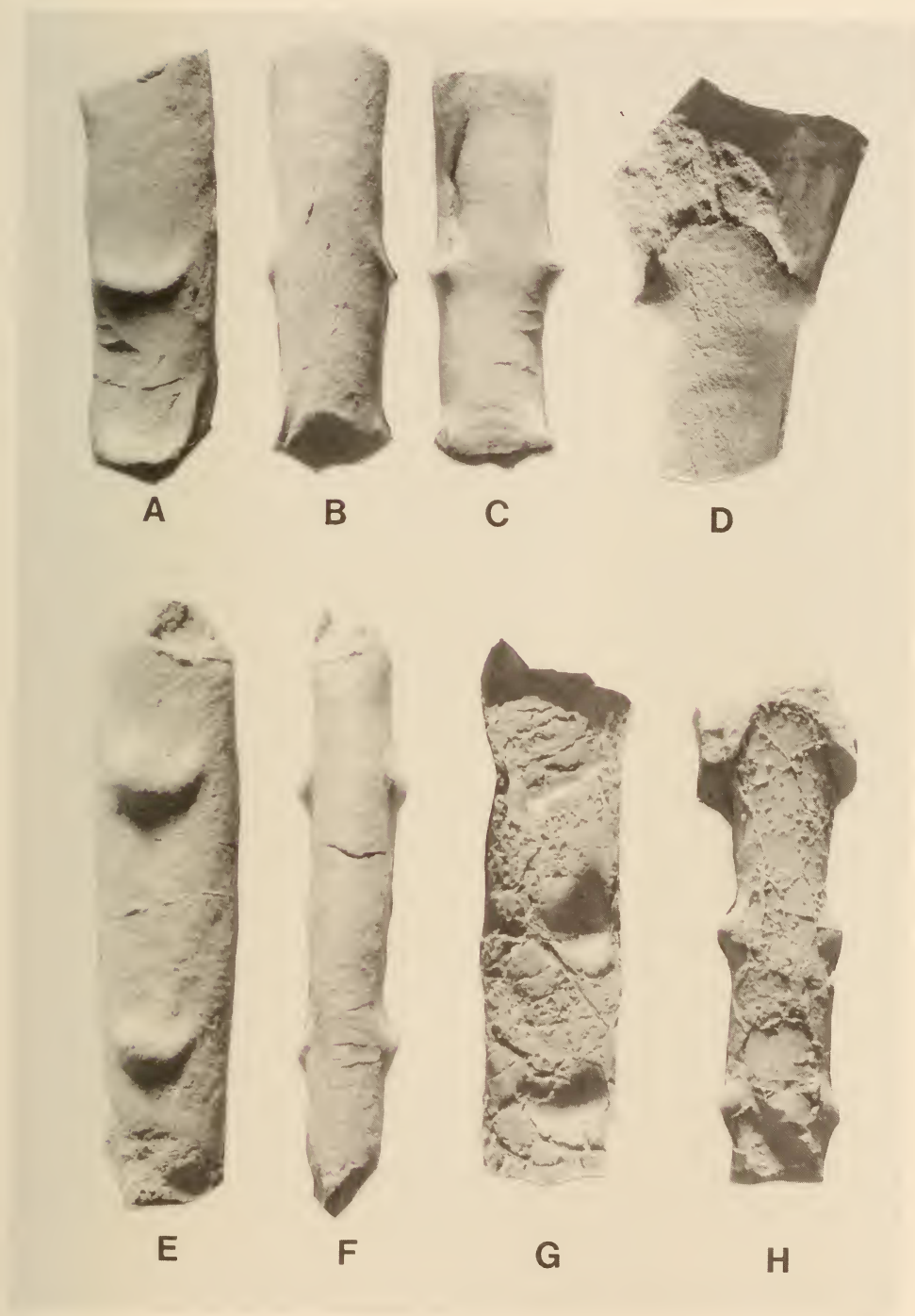


Fig. 92



Fig. 93. *Baculites vanhoepeni* Venzo, 1936. A-C. SAS A2035. Large, adult specimen with typical prominent auricular lateral tubercles. From locality 110, Zululand St Lucia Formation, Campanian II-?III. $\times 1$.

Fig. 94 (see facing page). *Baculites vanhoepeni* Venzo, 1936. A-C. SAS A2032. D. SAS A477. E. SAM-PCZ7411. F. SAM-PCZ8765. All from locality 110, Zululand, St Lucia Formation, Campanian II-?III. All $\times 1$.

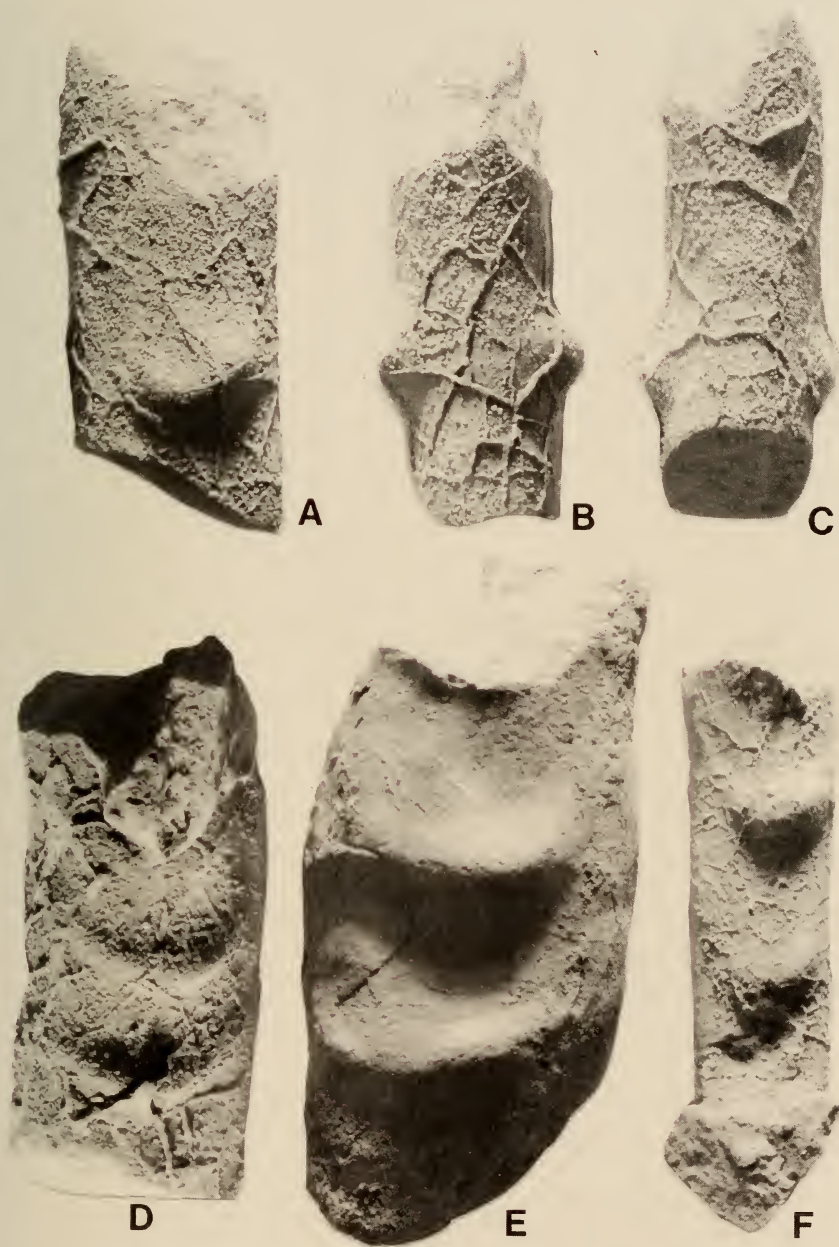


Fig. 94

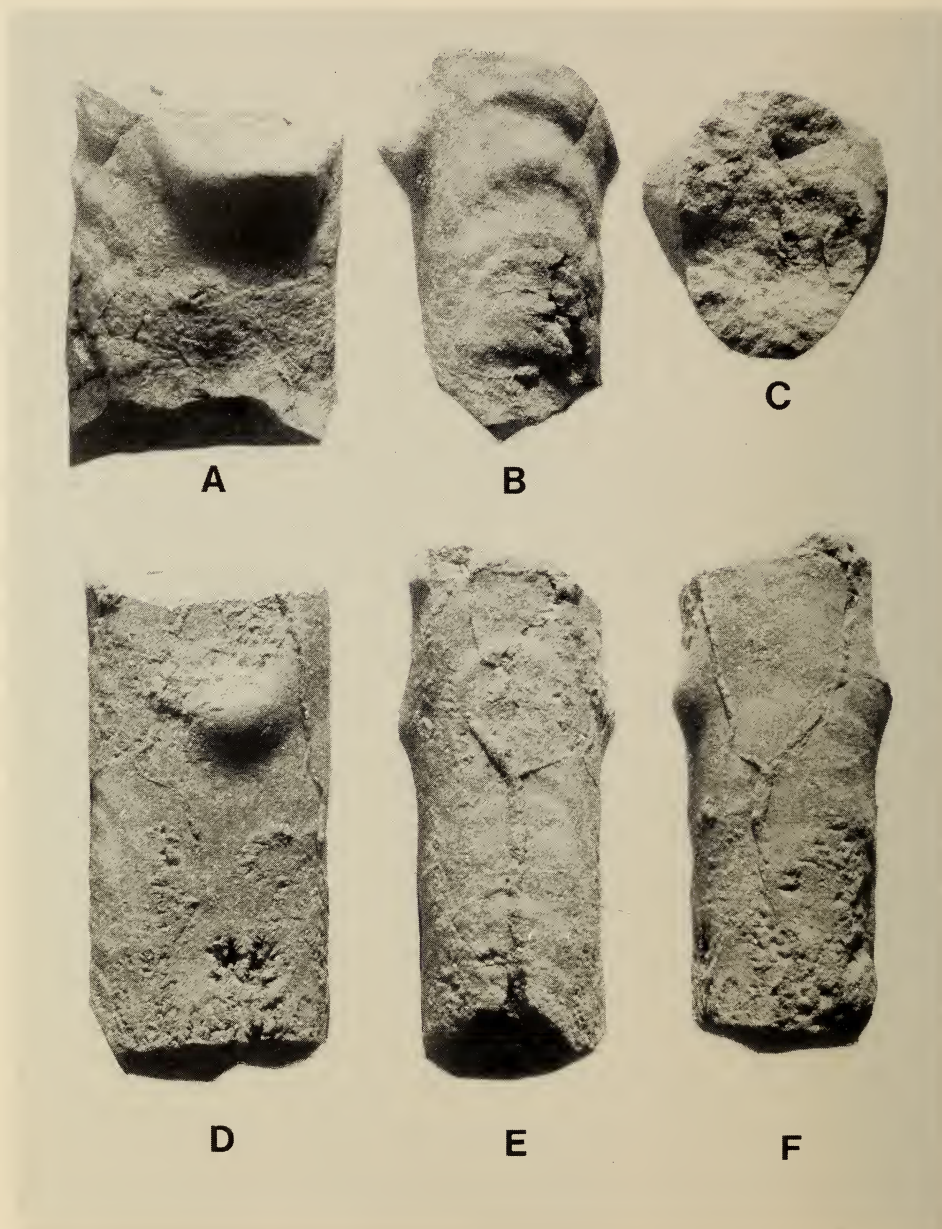


Fig. 95. *Baculites vanhoepeni* Venzo, 1936. A-C. SAM-PCZ7635. D-F. SAS A2034. Both from locality 110, Zululand, St Lucia Formation, Campanian II-?III. Both $\times 1$.

Fig. 96 (see facing page). *Baculites vanhoepeni* Venzo, 1936. A. SAM-PCZ7640. B. NMB D1302b. C-E. NMB D1302a. All from locality 110, Zululand, St Lucia Formation, Campanian II-?III. All $\times 1$.



Fig. 96

The dorsal projection of the bullae is striking. Viewed dorsally, their outline is pointed, mammiform and, together with the dorsal ribbing, forms an open-ended, inverted V. The whorl section varies from ovoid at the smaller end to elliptical at the larger.

The essential features of this species are the widely spaced, dorsolateral auricular bullae. In the adult stage, they are distinctly auricular in lateral view and conical mammiform in dorsal view. (Figs 96D, 99C). These are generally widely spaced, about one per twice the whorl height, but in some specimens, especially on the body chamber, they may be more closely spaced—up to three per whorl height (e.g. SAS A477—Fig. 94D), or even more widely spaced (e.g. PCZ9404, Fig. 102C), but this is exceptional.

There is some variation in the shape of the bullae. At the one extreme they are reduced to thin riblets on the flanks, e.g. Fig. 111A–C; at the other they are low and rounded to bullate, rather than transversely elongated, e.g. SAS A2034 (Fig. 95D–F), PCZ7640 (Fig. 96A), and Figures 110A–C, 112A–C, D, E–F. Specimens from locality 109A (Fig. 114A–C) have more widely spaced, smaller and rounded tubercles. We suspect that these are slightly older than typical forms at locality 109 and 110. These could also possibly be referred to as ?early forms of *B. vanhoepeni*, or, given more material, possibly be separated specifically.

The presence of riblets on the ventral half of the flanks and accompanying corrugation on the venter is an extremely variable feature and of no apparent taxonomic value. In some examples, e.g. PCZ8764 (Fig. 91A–C), PCZ7717 (Fig. 91D–F), PCZ1860h (Fig. 101D), PCZ1911 (Fig. 101F), these are quite distinct, but in the majority of specimens they are absent or very faint. The majority of specimens with ventral ribbing are small, but as shown in Figure 91, other specimens of similar size totally lack these ventral ribs. In short, ventral ribbing appears to be a variable character, sometimes, but not always associated with early stages of growth, and taxonomically of no significance in *B. vanhoepeni*.

The aperture is preserved in several specimens, e.g. Z1911 (Fig. 92D), Z1863e (Fig. 92G–H), Z2077 and consists of a short, rounded dorsal rostrum, a prominent lateral sinus and a longer ventral rostrum. Distribution of maximum whorl height (Fig. 113) suggests that *B. vanhoepeni* is dimorphic, but that some overlap in size occurs between macro- and microconchs. In one specimen, SAM–PCZ7091 (Fig. 91M–O) part of the body chamber is distinctly flared. This is very similar to a specimen of *B. obtusus* figured by Birkelund (1965, pl. 9 (fig. 3a–c)).

Fig. 97 (*see facing page*). *Baculites vanhoepeni* Venzo, 1936. A. SAS Z1860a. B. SAS A2029b. C. SAM–PCZ7655. D. SAS Z1860b. All from locality 110, Zululand, St Lucia Formation, Campanian II–?III. All $\times 1$.

Fig. 98 (*see overleaf*). *Baculites vanhoepeni* Venzo, 1936. A. SAS Z1190. B. SAS Z1860c. Both from locality 110, Zululand, St Lucia Formation, Campanian II–?III. Both $\times 1$.

Fig. 99 (*see overleaf*). *Baculites vanhoepeni* Venzo, 1936. A. SAS Z1911. Specimen with typical adult lateral ornament. D. SAS A2029a. E. SAM–PCZ12020. F. NMBD1302a. All from locality 110, Zululand, St Lucia Formation, Campanian II–?III. All $\times 1$.

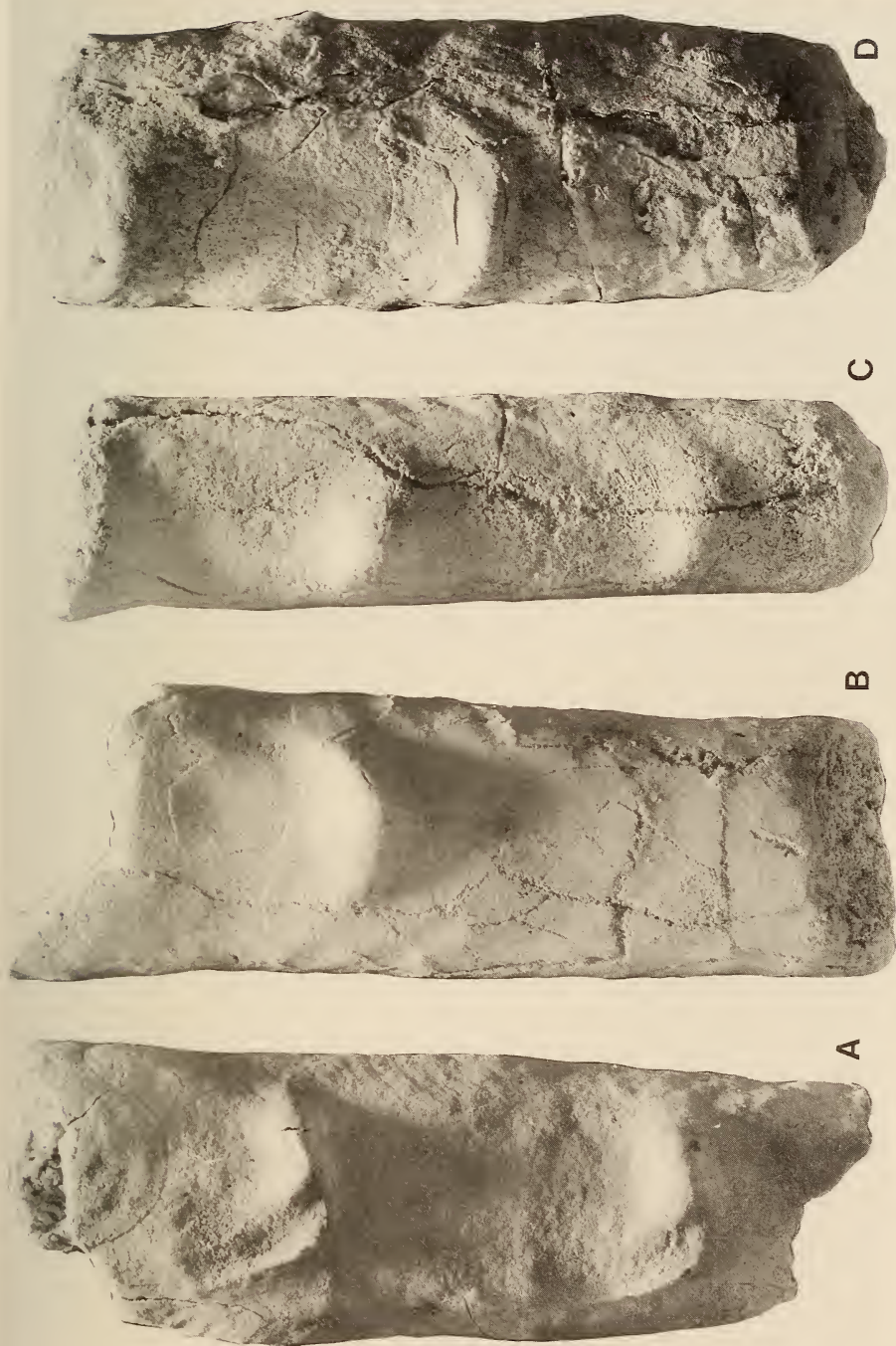


Fig. 97



Fig. 98

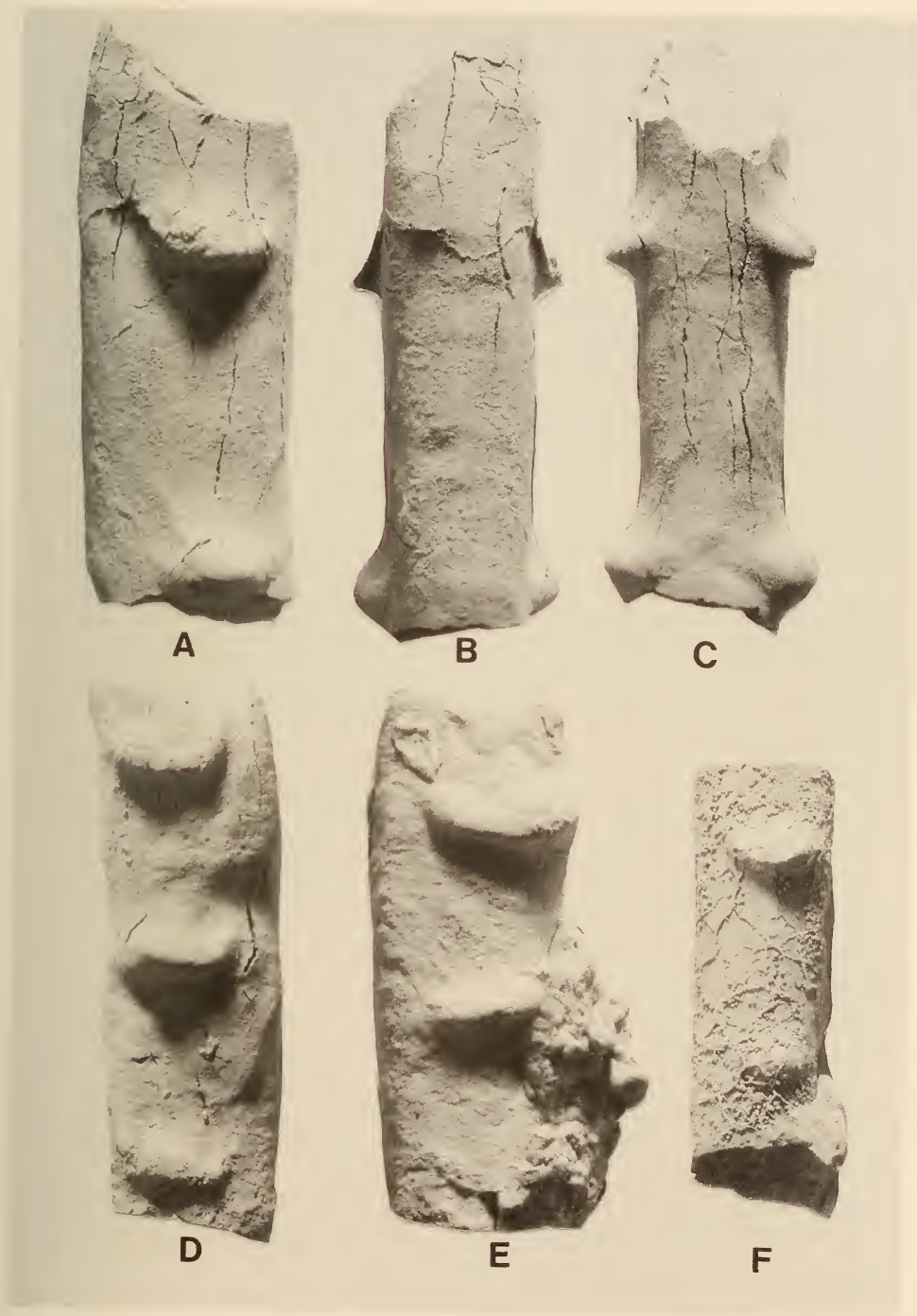


Fig. 99

The suture line of *B. vanhoepeni* (Figs 104–108) is slightly more complex than that of the majority of the Lower and Middle Campanian baculitid species from Madagascar (Figs 61–62, 85) and quite variable. The lateral lobe (L) tends to become constricted. In some, e.g. Z1923 (Fig. 108A), the suture is highly incised and dendritic, with narrow-stemmed saddles and a prominent, asymmetrically trifold, constricted lateral lobe, whereas in others (e.g. SAM-PCZ7706—Fig. 104A) it is relatively simple with quadrate saddles and lobes with open (unconstricted) lobes.

Discussion

This species was originally described as *B. vagina* var. *van Hoepeni* by Venzo (1936: 116 [58], pl. 10 [6] (figs 11–12)). Venzo incorrectly included the Pondoland specimens described and figured by Van Hoepen (1921: 18, pl. 3 (figs 7–8)) as *B. sulcatus* in the synonymy of this species. *Baculites vagina* is a typical Maastrichtian *Eubaculites*, and totally different from the present species, bituberculate, with a tabulate venter (see e.g. Klinger & Kennedy 1993). *Baculites sulcatus*, as here interpreted, is an older species, occurring in the Lower Campanian of Pondoland, and typically lacks the strong lateral ornament of *B. vanhoepeni*.

Baculites vanhoepeni is easily identified by the distinct, auricular dorsolateral ornament, especially in the adult stage, and, most conspicuously, by its large size, which distinguishes it from all the older Lower and other Middle Campanian baculitid species of Zululand and Madagascar.

Juvenile stages of *B. vanhoepeni* are rare, probably for taphonomic and/or diagenetic reasons. Available specimens (Fig. 109H) are indistinguishable from similarly sized specimens of *B. increscens* (Fig. 79I–J) or *B. sulcatus* (Fig. 73I). This suggests a phylogenetic lineage starting with *B. capensis*, via *B. sulcatus* and *B. increscens* or similar forms, to *B. vanhoepeni*. The adult stages, however, are clearly different—both in terms of ornament and maximum adult size.

As mentioned above, there is some variation in lateral ornament. Typical specimens have widely spaced, auricular bullae but, in some, the bullae are reduced to thin lateral riblets (Fig. 111A–D), or the bullae are more closely spaced and sharp crested (Fig. 94D), whereas in some the bullae are large and rounded and mammiform (Figs 95D–F, 96A). Some of these morphologies are already present in some of the Lower and Middle Campanian baculitids of Madagascar described by Collignon (1969, 1970).

Fig. 100 (*see facing page*). *Baculites vanhoepeni* Venzo, 1936. A–B. SAS Z1860d. C–E. SAM-PCZ7645. Both from locality 110, Zululand, St Lucia Formation, Campanian II–?III. Both $\times 1$.

Fig. 101 (*see overleaf*). *Baculites vanhoepeni* Venzo, 1936. A. SAM-PCZ7786. B. SAM-PCZ7690. C. SAS A2036a. D. SAS Z1860h. E. SAS A2036. F. SAS Z1911. G. SAS Z1923. H. SAS Z1860f. All from locality 110, Zululand, St Lucia Formation, Campanian II–?III. All $\times 1$.

Fig. 102 (*see overleaf*). *Baculites vanhoepeni* Venzo, 1936. A–B. SAS Z1860b. C. SAM-PCZ9404. Both from locality 110, Zululand, St Lucia Formation, Campanian II–?III. Both $\times 1$.



Fig. 100

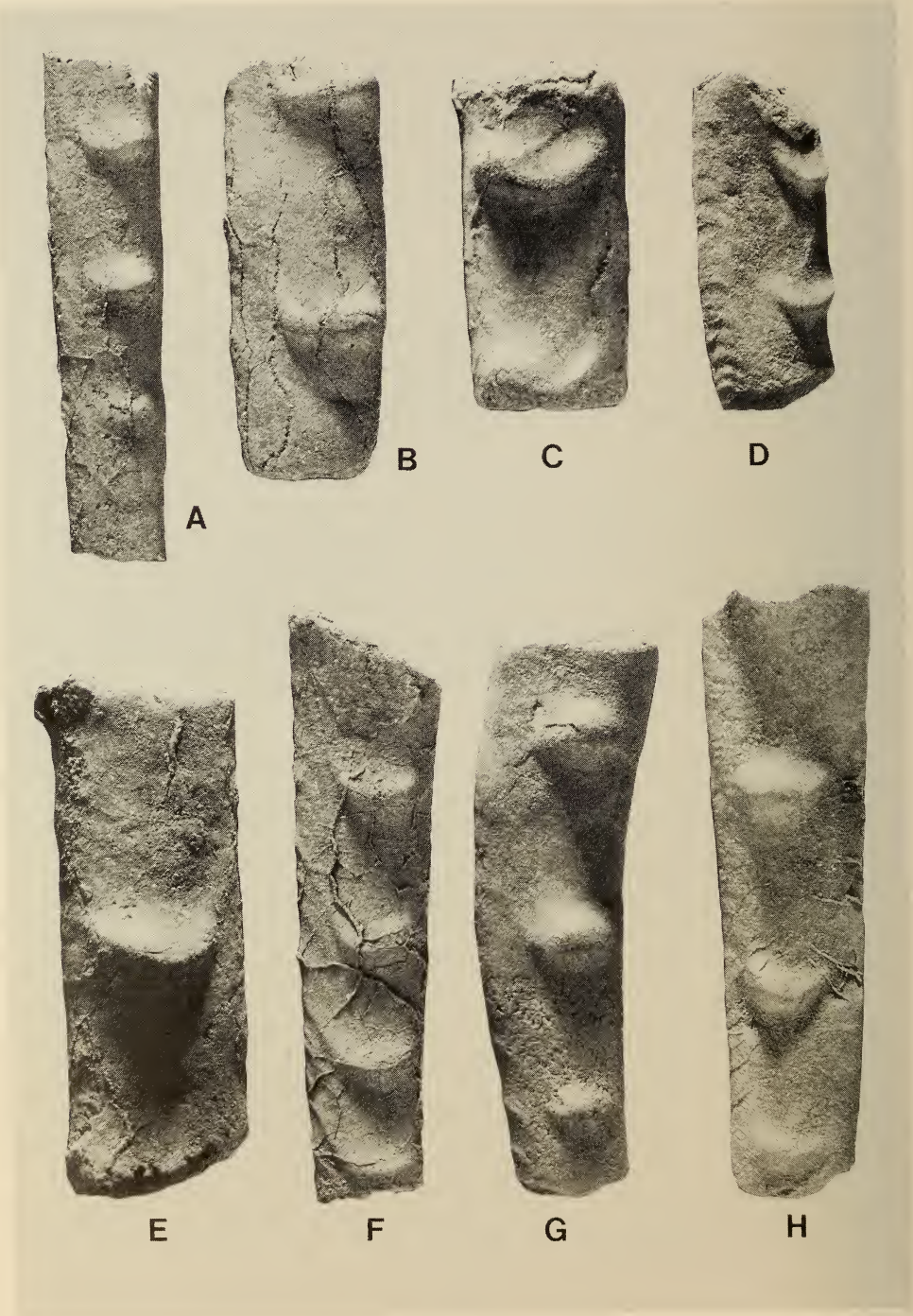


Fig. 101

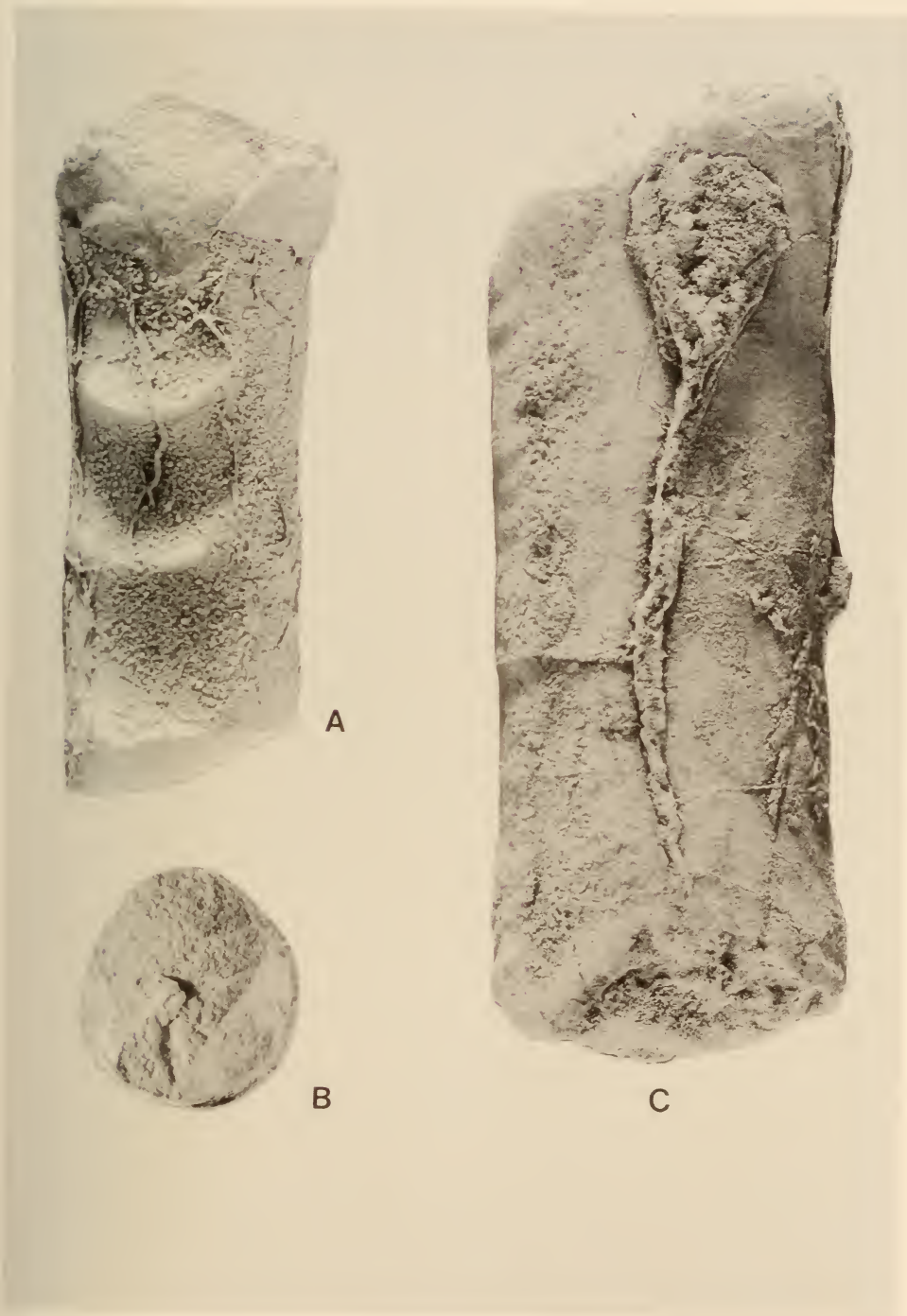


Fig. 102



Fig. 103. *Baculites vanhoepeni* Venzo, 1936. NMBD1320b. One of the largest specimens of this species from locality 110, Zululand, St Lucia Formation, Campanian II-?III. $\times 1$.

Large, mammiform nodes already occur in Lower Campanian *B. sparsinodosus* (Fig. 60) and are well developed in *B. mamillatus* (Fig. 84A-C) in the Middle Campanian. Thin, rib-like ornament, albeit very closely spaced, occurs in *B. coagmentatus* (Fig. 88) and *B. leopoliensis* Collignon *non* Nowak (= *Baculites collignoni* nom. nov.) (Fig. 86) in the Middle Campanian of Madagascar.

We initially thought (Klinger & Kennedy 1977: 74) that *B. tanakae* Matsumoto & Obata (1963: 51, pl. 13 (fig. 4), pl. 16 (figs 1-5), pl. 17 (figs 1-5), pl. 18 (figs 1, 3-4), pl. 19 (figs 1, 4), text-figs 97-113, 115) was a synonym of *B. vanhoepeni*, but now rather regard it as being closer to *B. capensis* than to *B. vanhoepeni* as discussed above (p. 109), and probably a senior synonym of *B. menabensis* Collignon.

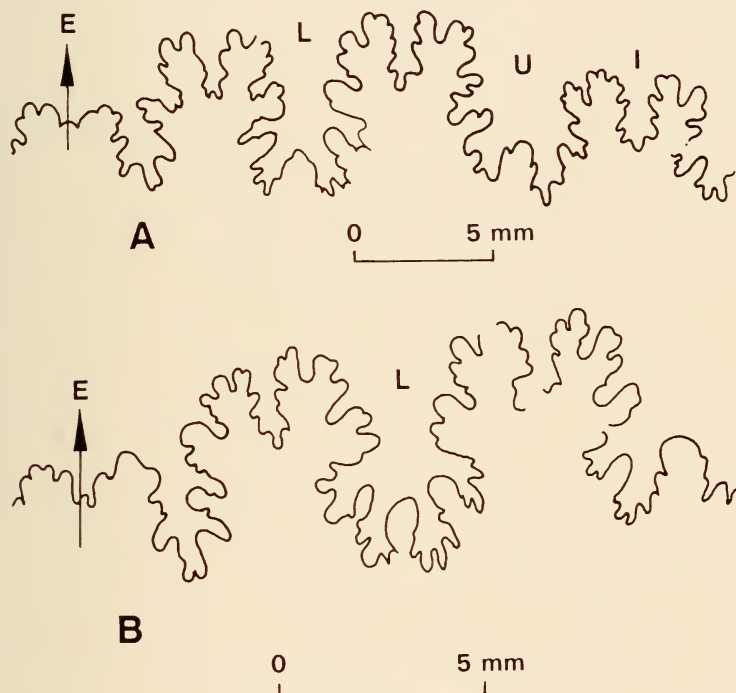


Fig. 104. *Baculites vanhoepeni* Venzo, 1936.
Suture lines. A-B. SAM-PCZ7706.
Scale bar for size.

Baculites taylorensis Adkins (1929: 204, pl. 5 (figs 9-11)), recently revised by Kennedy & Cobban (1993a: 93, figs 10.1-10.9, 10.11-10.12, 10.16, 10.18-10.19; 11.1-11.2; 1993d: 143, pl. 6 (figs 1-9), pl. 7 (figs 1-6, 10-13), text-fig. 8b, d), from the Middle Campanian Taylor Formation of Texas and the Annona Chalk in Arkansas, is indistinguishable from *B. vanhoepeni* on the basis of the original descriptions and figures of Adkins. The specimens figured by

Kennedy & Cobban, however, all seem to be consistently more weakly ornamented than *B. vanhoepeni* and more like *B. sparsinodosus*.

Matsumoto & Obata (1963: 55) also noted the parallelism between the lineages of *B. capensis*–*B. tanakae* in the Indo-Pacific region, and *B. codyensis* (as *B. asper*)–*B. taylorensis* in the Gulf–Atlantic region. In both lineages, which cover more or less the same time interval, there is a progressive increase in size, and coarsening and wider spacing of ornament.

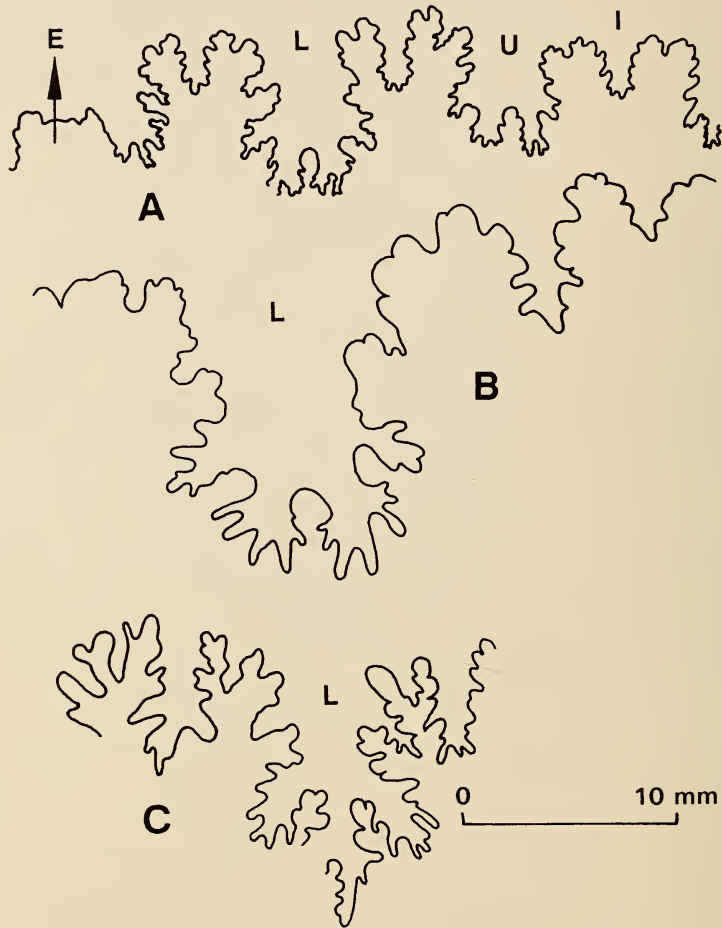


Fig. 105. *Baculites vanhoepeni* Venzo, 1936. Suture lines.
A–B. NMBD1302. C. SAM-PCZ7640.
Scale bar for size.

Baculites sp. (in Stephenson 1941: 407, pl. 76 (figs 7–8)) has similar lateral ornament, but the dorsum seems more flattened—as in *B. nibelae* sp. nov. According to Matsumoto (1959: 126), the former may be a representative of *B. lomaensis* Anderson (1958: 191, pl. 48 (figs 5–6)). The latter, however, apparently occurs in the Lower Maastrichtian of California.

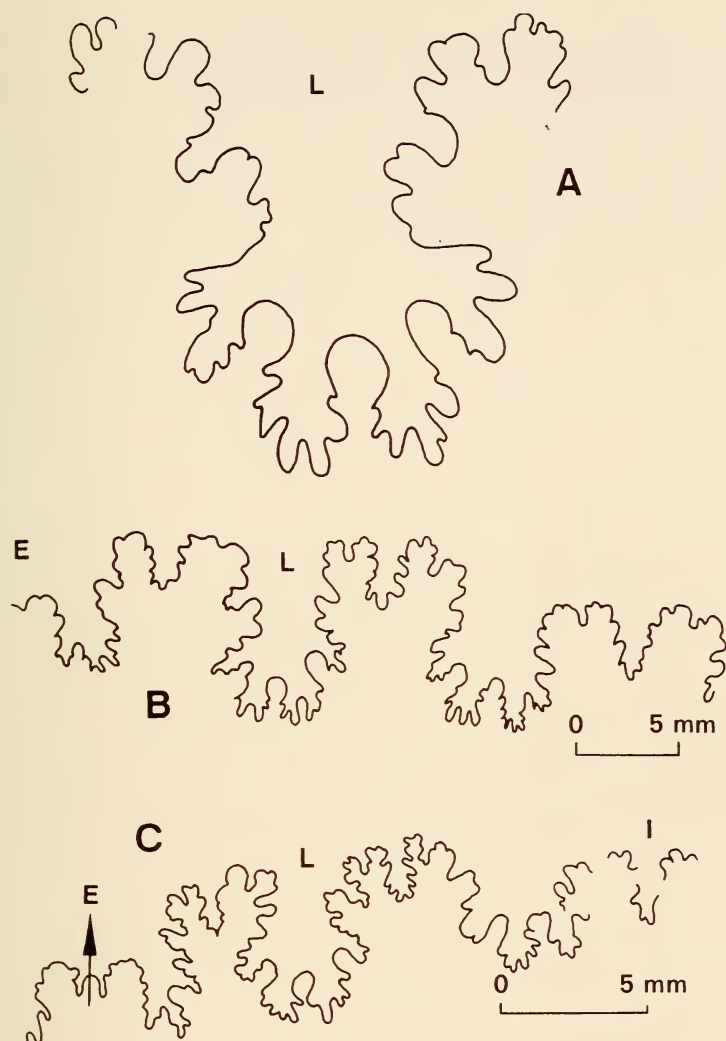


Fig. 106. *Baculites vanhoepeni* Venzo, 1936. Suture lines.

A-B. NMBD1302. C. SASZ1191.

Scale bar for size of B and C.

A similar convergent lineage occurs in the Middle Campanian of the U.S. Western Interior, consisting of *B. obtusus*-*B. maclearni*-*B. asperiformis*. The latter part of this lineage, *B. asperiformis*, is remarkably similar to *B. vanhoepeni*; compare e.g. *B. asperiformis* in Cobban (1962, pl. 106 (figs 10-11)) and Figure 91. The lateral ornament is identical, as is the occurrence of ventral ribbing. The sutures are also similar, although some specimens of *B. vanhoepeni* may have a more complex, dendritic suture. However, the early part of this lineage, *B. obtusus*, has closely spaced

dorsolateral crescentic ribs and a strongly corrugated venter—quite unlike any of the Indo-Pacific material. *Baculites vanhoepeni* can perhaps be considered analogous to *B. obtusus*, but there are sufficient differences to separate them.

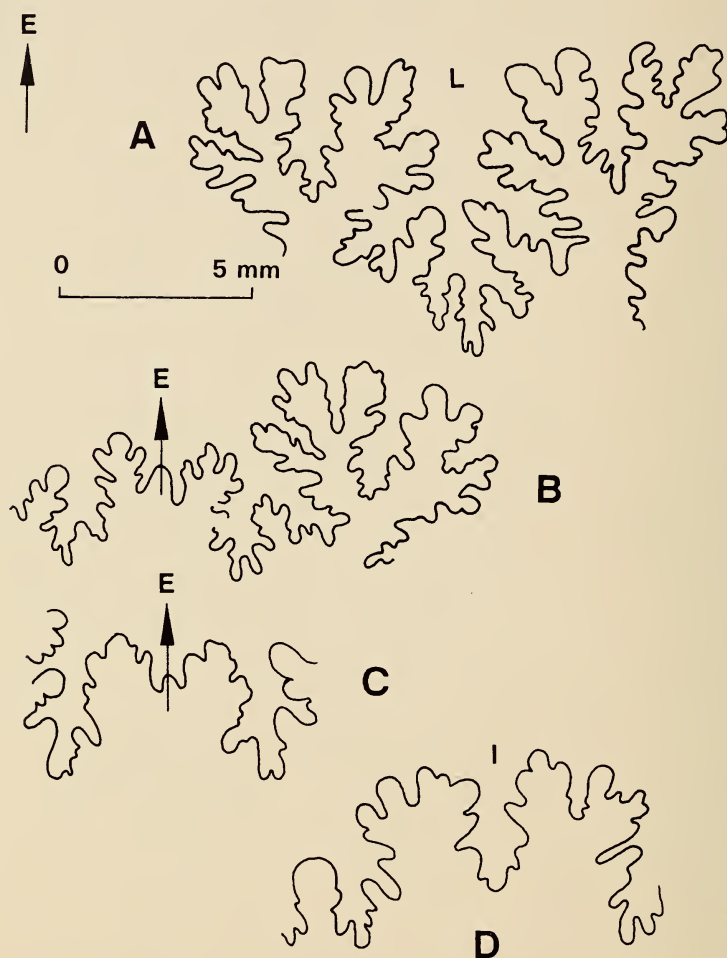


Fig. 107. *Baculites vanhoepeni* Venzo, 1936. Suture lines. A-D. SAS Z1923. Specimen with complex suture line and constricted lateral lobe (L). See also Fig. 108.
Scale bar for size.

As far as the ornament is concerned, small specimens of *B. vanhoepeni* show a remarkable similarity to *Boehmoceras arculus* from the U.S. Gulf Coast described by Kennedy & Cobban (1991b), already referred to above (p. 121). Apart from the lack of the distinct curvature, specimens of *B. vanhoepeni*, e.g. Figure 91A-O are indistinguishable from *B. arculus* in Kennedy & Cobban (e.g. 1991b: fig. 9.11-52). Some specimens of *B. vanhoepeni*, e.g. PCZ8764 (Fig. 91A-C), do show slight curvature, but nowhere as pronounced as in

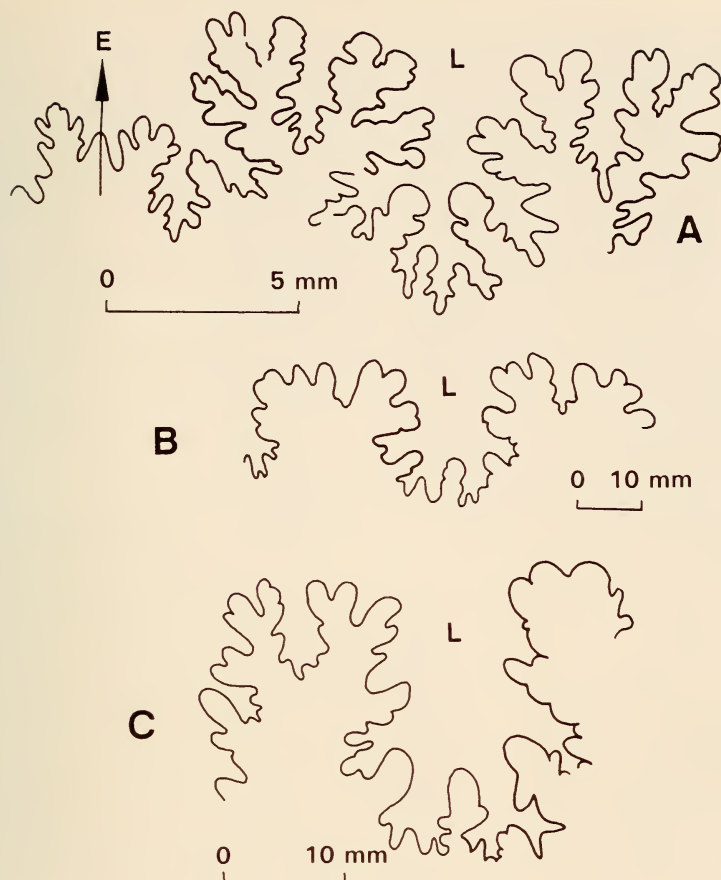


Fig. 108. *Baculites vanhoepeni* Venzo, 1936. Suture lines.
 A. SAS Z1923. Extremely complex, dendritic suture compared to other specimens. B. SAS A2029. C. SAS A2034.
 Scale bar for size.

Boehmoceras arculus. Apart from the curvature, *B. arculus* is an older species, occurring in the Upper Santonian, whereas *B. vanhoepeni* is definitely younger, occurring in the Middle to Upper Campanian of Zululand.

It thus appears that three, apparently unrelated baculitid lineages in the Indo-Pacific, the Gulf Atlantic and the U.S. Western Interior, respectively, gave rise in the Middle Campanian to remarkably similar forms with prominent, widely spaced arcuate bullae, viz. *B. vanhoepeni*, *B. taylorensis* and *B. asperiformis*. Another lineage gave rise to similar ornament in *Boehmoceras* in the Upper Santonian. This is a remarkable example of both isochronous and heterochronous homoeomorphy. It also illustrates the difficulties in trying to identify baculites on isolated specimens on the basis of ornament alone. A fuller discussion on these aspects of baculitid evolution is covered in Klinger & Kennedy (in press).

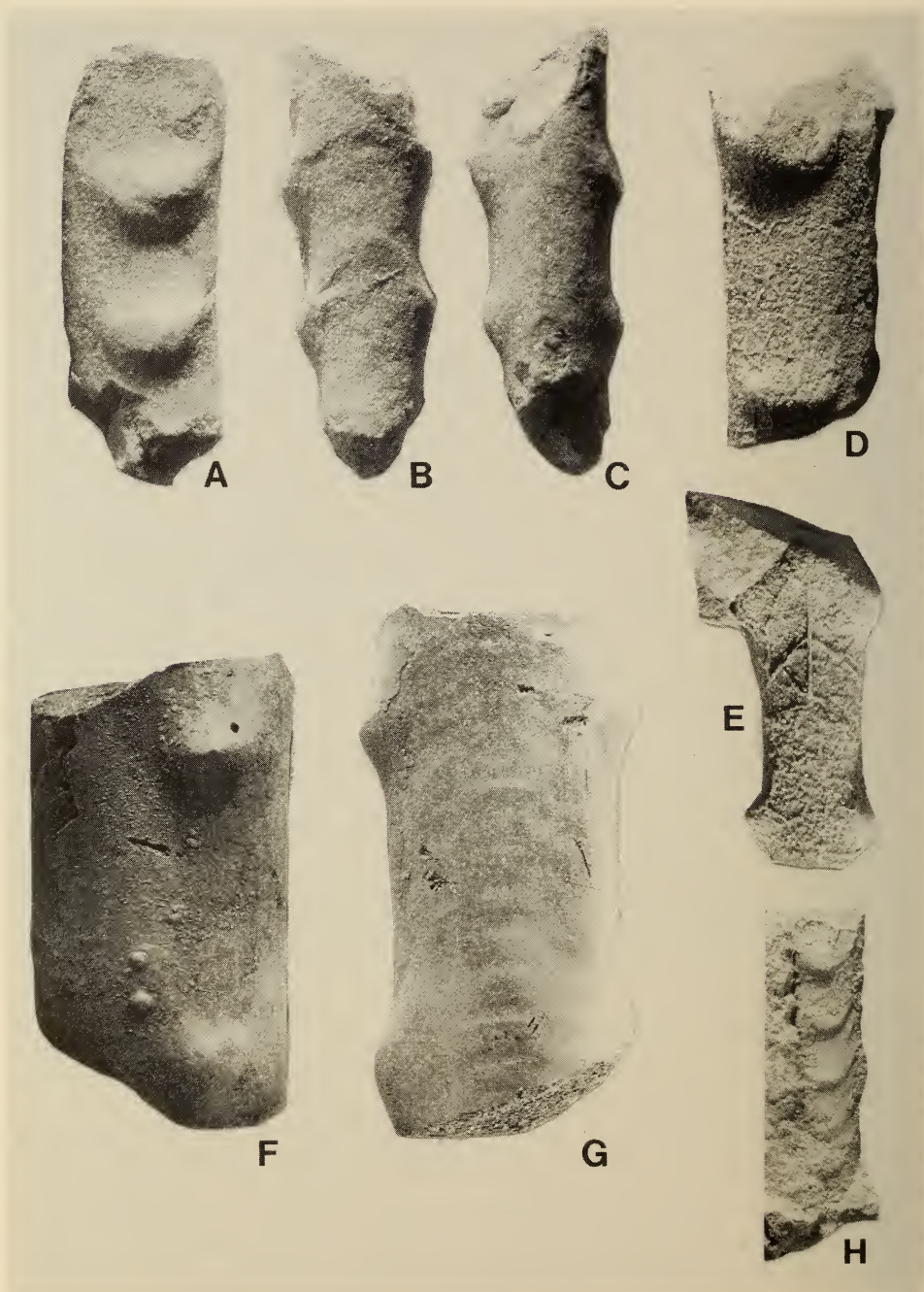


Fig. 109. *Baculites vanhoepeni* Venzo, 1936. A-C. SAS Z1868. D-E. SAM-PCZ7705. H. SAM-PCZ7714, all from locality 110, Zululand, St Lucia Formation, Campanian II-?III. F-G. From the collections of the Geology Department, University of Natal, from locality 4, Durban, Mzamba Formation, Campanian II. All $\times 1$.

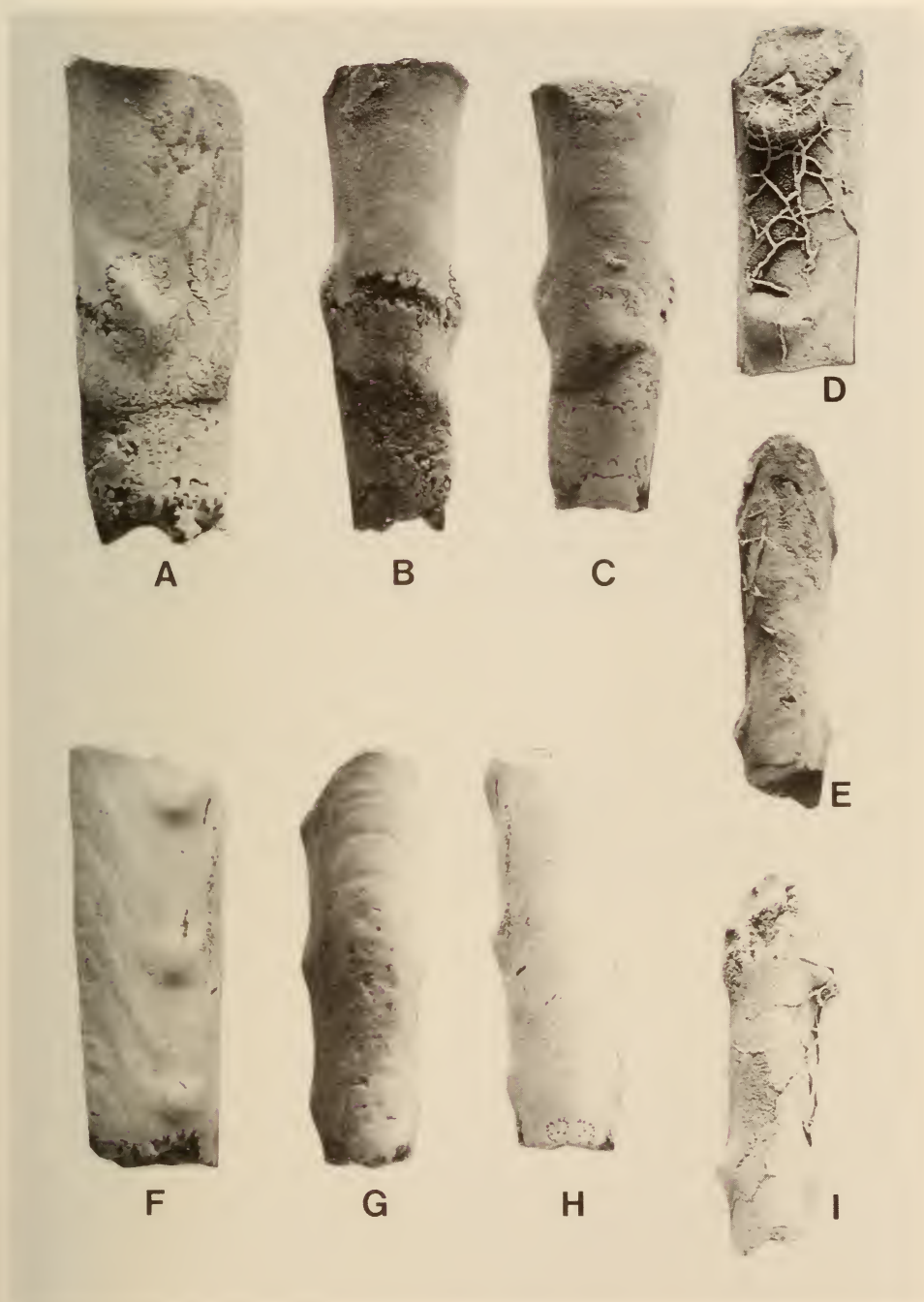


Fig. 110. *Baculites vanhoepeni* Venzo, 1936. A-I. Three unregistered specimens in the collections of the Geology Department, University of Natal, from locality 4, Durban, Mzamba Formation, Campanian II. All $\times 1$.

Kennedy (1986b: 110, pl. 17 (figs 7–9, 13–15, 21–23), pl. 18 (figs 18–22), pl. 23 (figs 1, 7), text-fig. 8A, C) informally described a baculitid from the Upper Campanian of France as *Baculites* sp. 1. *Baculites vanhoepeni* was regarded as being closest to this informally named baculitid. In addition, Holzapfel's (1888: 64, pl. 4 (figs 5–6)) and Müller & Wollemann's (1906: 4, pl. 2 (figs 2–5)) *Baculites incurvatus* were regarded as belonging to this species. As discussed above, *B. incurvatus* is a Coniacian–Santonian species, and the German records from the Lower Campanian are obvious misidentifications. They seem closer to the Madagascan *B. menabensis*, which in turn is probably a synonym of *B. tanakae*.

Some of the larger French specimens figured by Kennedy (e.g. 1986b, pl. 18 (figs 18–22)) have ornament comparable to that of *B. vanhoepeni*, but more material is necessary for definite comparisons.

Occurrence

Baculites vanhoepeni typically occurs with a Middle Campanian texanitid fauna of *Australiella* and *Delawarella*, but we suspect that it ranges into the Upper Campanian by its association with *Hoplitoplacenticeras howarthi*, both at locality 110 in Zululand (Klinger & Kennedy 1989), and at Somtseu, Durban (Kennedy & Klinger 1973).

Baculites nibelae sp. nov.

Figs 116–120

- ? 1970 *Baculites* cf. *taylorensis* Adkins; Collignon, p. 13, pl. 612 (fig. 2285).
 ? 1970 *Baculites* sp. (nov.?) cf. *aquilaensis* Reeside; Collignon, p. 81, pl. 639 (fig. 2358).

Type

Holotype is SAM-PCZ9148b from locality 111, cliff section just east of the Nibela Peninsula, Zululand, St Lucia Formation, Campanian III.

Material

Paratypes are SAM-PCZ7570, 7578, 7625, 7629, 7644, 7698a–e, 7702, 7850, 9155, 9163 and 9166, all from locality 109C; SAM-PCZ7569 from locality 109A, SAM-PCZ7631a, 7699, 7630, 7632, 7700 and 7701, from locality 109D, all on the western shores of the Nibela Peninsula, Zululand, St Lucia Formation, Campanian III; and SAM-PCZ9146, 9147, 9148a–e, 9149a–f, 9150a–g and 9151–9154, all from locality 111, St Lucia Formation, Campanian III.

Fig. 111 (see facing page). *Baculites vanhoepeni* Venzo, 1936. Two unregistered specimens in the collections of the Geology Department, University of Natal, from locality 4, Durban, Mzamba Formation, Campanian II. Note similarity of A–C to *Baculites collignoni* nom. nov. (see Fig. 96). All $\times 1$.

Fig. 112 (see overleaf). *Baculites vanhoepeni* Venzo, 1936. Three unregistered specimens in the collections of the Geology Department, University of Natal, from locality 4, Durban, Mzamba Formation, Campanian II. Note similarity to *Baculites mamillatus* (see Fig. 84A–C). All $\times 1$.

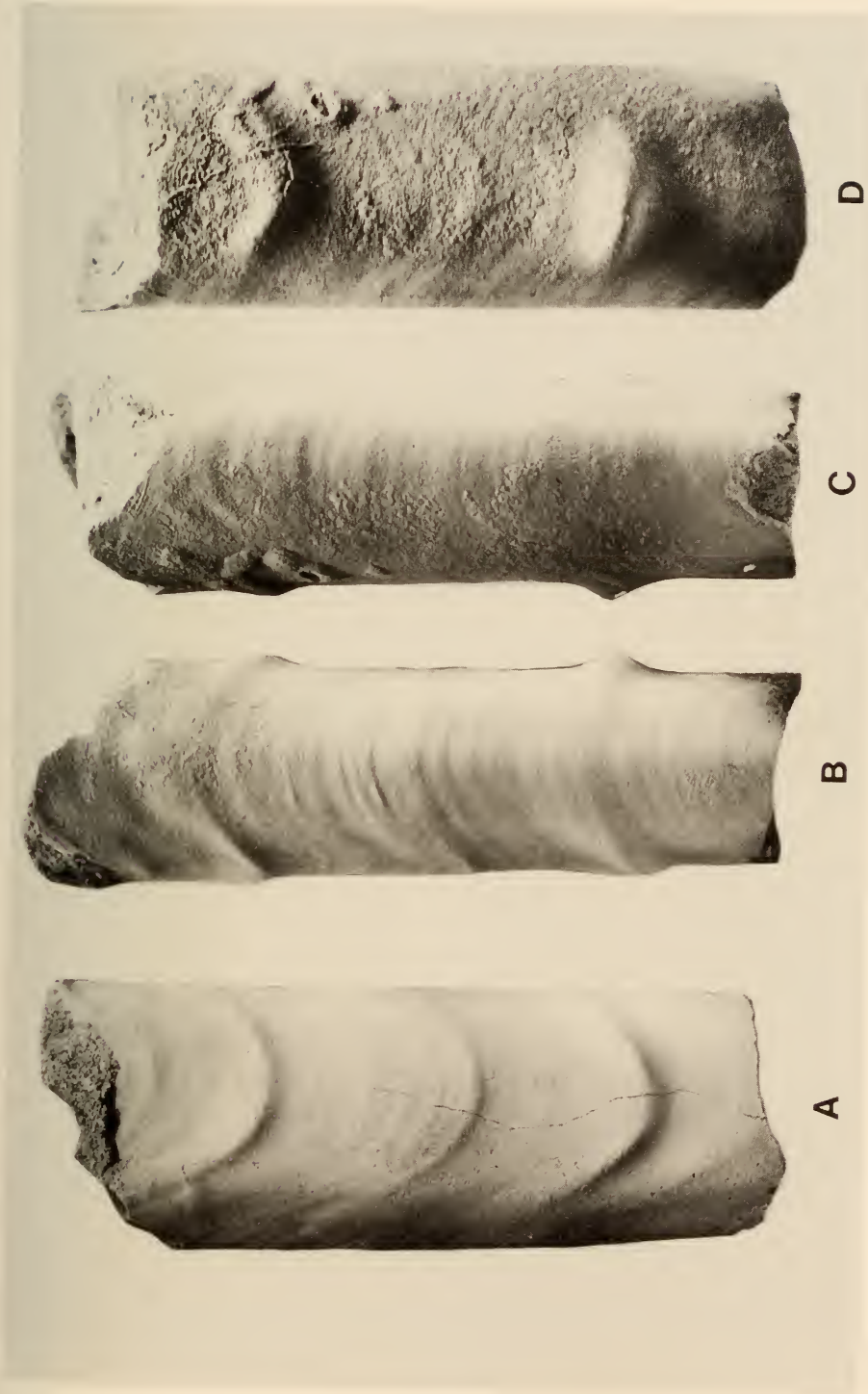


Fig. 111



Fig. 112

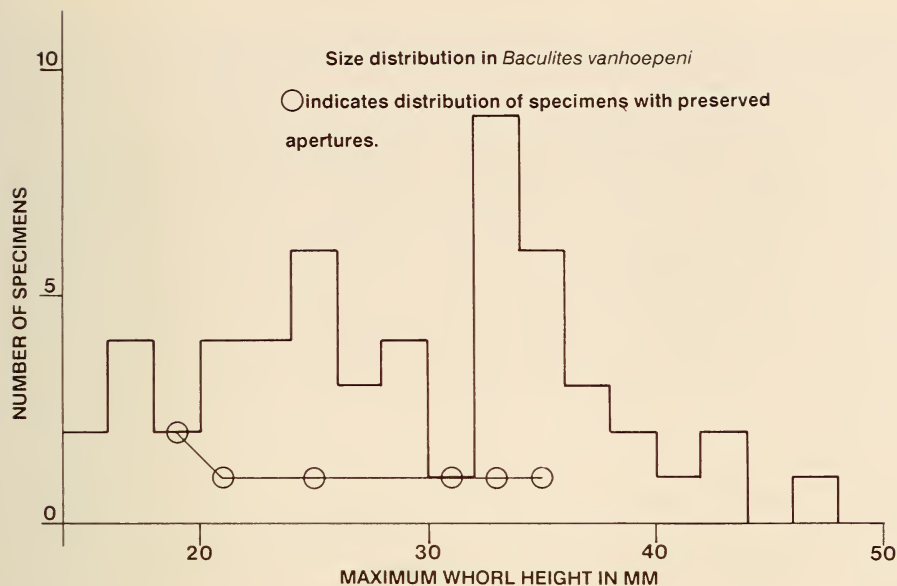


Fig. 113. Histogram illustrating maximum size distribution in *Baculites vanhoepeni* Venzo, 1936. Open circles indicate specimens with the aperture preserved.

Dimensions

Specimen	MxWb	MxWh	Wb/Wh	MnWb	MnWh	Wb/Wh	D	Ti	Ri
PCZ7578	26.0	34.0	0.76	—	—	—	—	—	—
PCZ9148b	22.0	29.0	0.76	18.0	26.0	0.70	96	3.1	2½
PCZ7698a	21.0	29.0	0.72	—	—	—	—	—	—
PCZ7699	21.0	29.0	0.72	—	—	—	—	—	—
PCZ9148a	20.0	27.0	0.74	17.0	22.0	0.77	70	7.1	—
PCZ9153	20.0	30.0	0.67	19.0	28.0	0.68	68	7.1	2½
PCZ9149b	18.0	23.0	0.78	16.0	23.0	0.7	52	—	2½
PCZ9149d	18.0	25.0	0.72	—	—	—	—	—	—
PCZ7631	17.5	24.0	0.73	—	—	—	—	—	—
PCZ9149a	—	15.0	—	—	12.0	—	54	5.6	2½
PCZ9148e	10.0	14.0	0.71	9.0	13.0	0.61	60	1.7	2½

Diagnosis

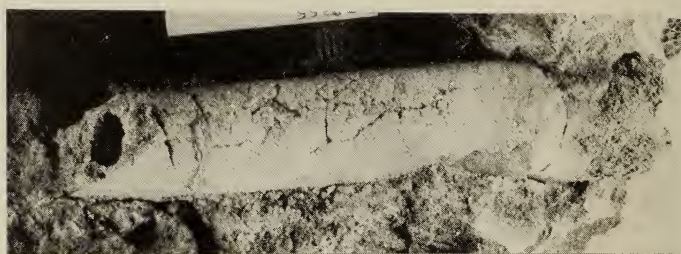
Baculitid with subtrigonal whorl section and arcuate lateral ornament.

Description

The maximum observed whorl height is 34 mm. In typical forms the whorl section is subtrigonal with a distinctly flattened dorsum and flanks converging to a rounded venter (Fig. 118B-G). In juvenile specimens the whorl section is distinctly ovoid to tear-shaped with the venter much narrower than the dorsum.



A



B



C

Fig. 114. *Baculites vanhoepeni* Venzo, 1936. ?Early forms. A-B. SAM-PCZ9255. C. SAM-PCZ9252. Both from locality 109A, Zululand, St Lucia Formation, Campanian II. All $\times 1$.

Fig. 115 (see facing page). *Baculites vanhoepeni* Venzo, 1936. A-C. Typical form, SAM-PCZ9284 from locality 110. D-F. SAM-PCZ9131, ?early form, from locality 109A. Both $\times 1$.



Fig. 115



Fig. 116. *Baculites nibelae* sp. nov. The holotype, SAM-PCZ9148, from locality 111, St Lucia Formation, Campanian III. $\times 1$.

Fig. 117 (see facing page). A-D, F-I. *Baculites nibelae* sp. nov. A. SAM-PCZ9148a. B. SAM-PCZ9149a. C-D. SAM-PCZ9150e. Specimen with part of aperture preserved. F-H. SAM-PCZ9153. I. SAM-PCZ7631. All from locality 111, St Lucia Formation, Campanian III. E. *Baculites duharti* Hünicken, 1975. SAM-PCZ9873c, from concretion at base of cliff at locality 110, Zululand, St Lucia Formation, Campanian II. All $\times 1$.

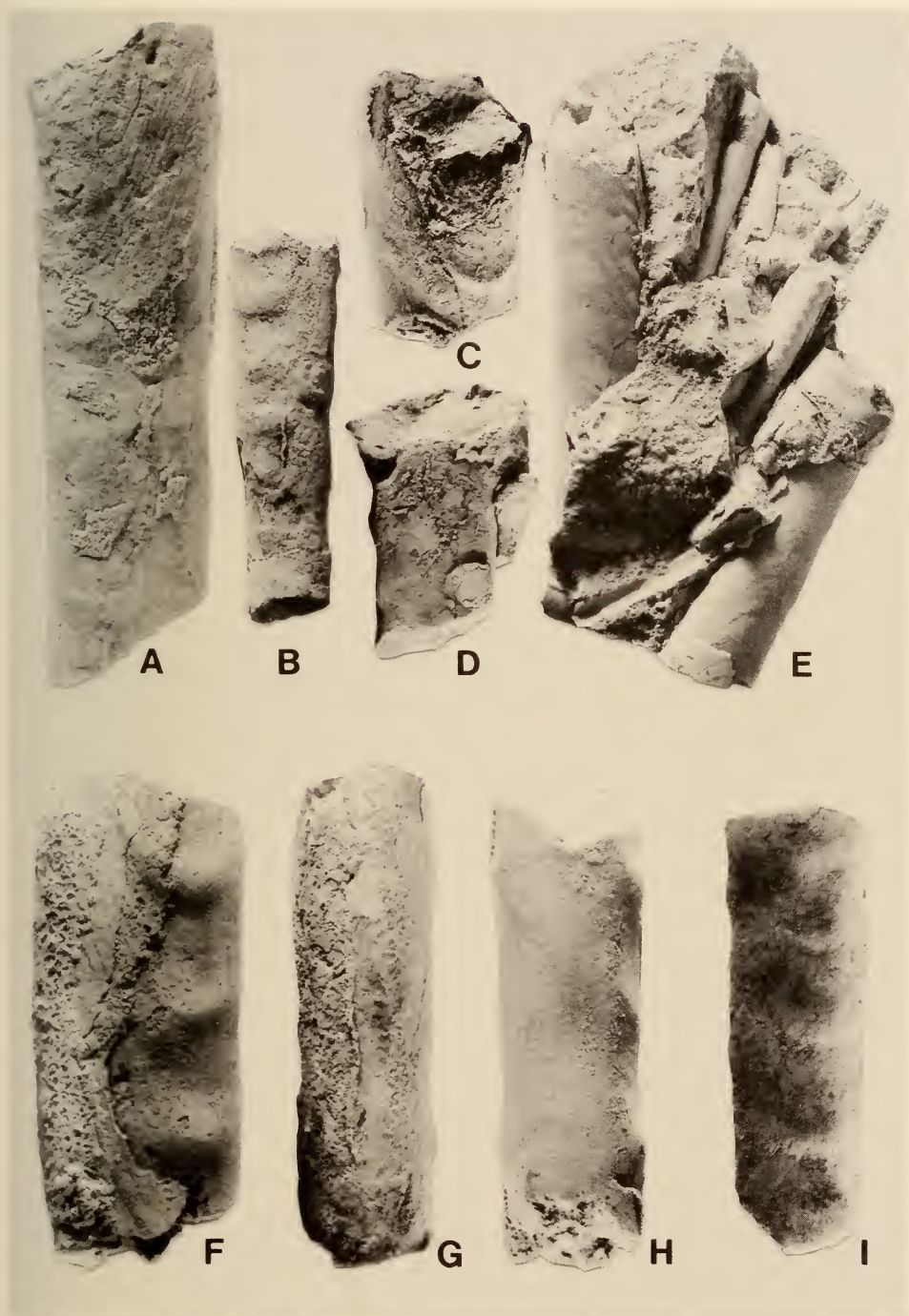


Fig. 117

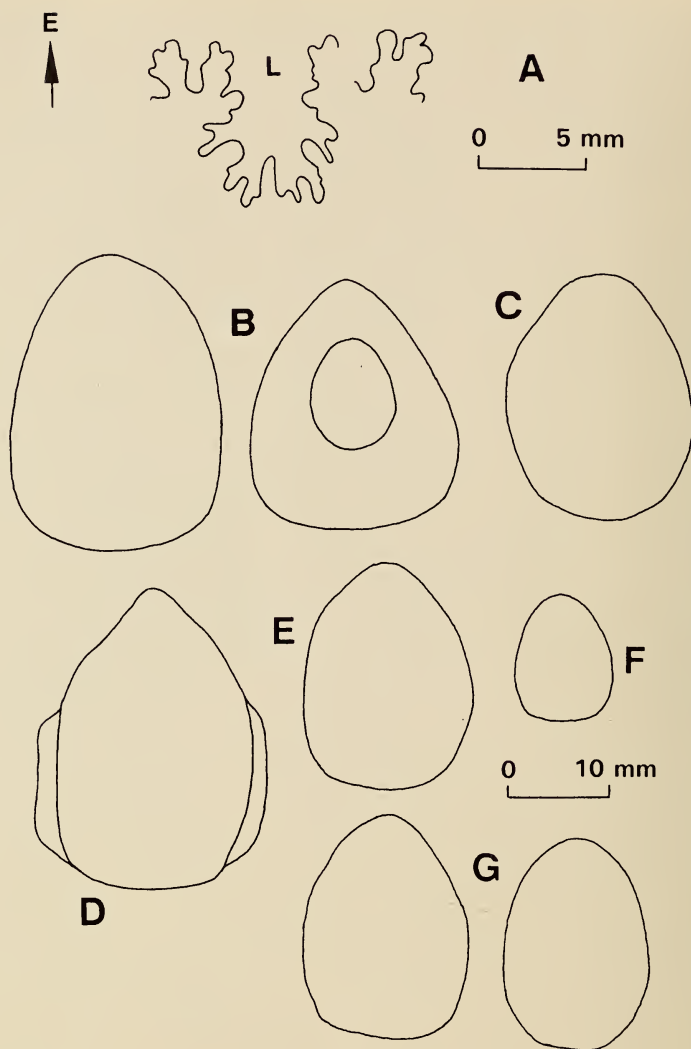


Fig. 118. *Baculites nibelae* sp. nov. Partial suture line and whorl sections.
 A. SAM-PCZ7630. B. SAM-PCZ7631. C. SAM-PCZ7701.
 D. SAM-PCZ7644. E. SAM-PCZ7630. F. SAM-PCZ7631.
 G. SAM-PCZ7698. Venter in whorl section facing upward.
 Scale bar for size.

Fig. 119 (see facing page). *Baculites nibelae* sp. nov. A. SAM-PCZ7702. B-D. SAM-PCZ7361a. E-F, I. SAM-PCZ7578. G. SAM-PCZ7698. H. SAM-PCZ9153. All from locality 109, Zululand, St Lucia Formation, Campanian III. All $\times 1$.

Fig. 120 (see overleaf). *Baculites nibelae* sp. nov. A. SAM-PCZ7630. B-D. SAM-PCZ12021. E. SAM-PCZ9149. F. SAM-PCZ7698. G. SAM-PCZ9148e. All from locality 109, Zululand, St Lucia Formation, Campanian III. All $\times 1$.

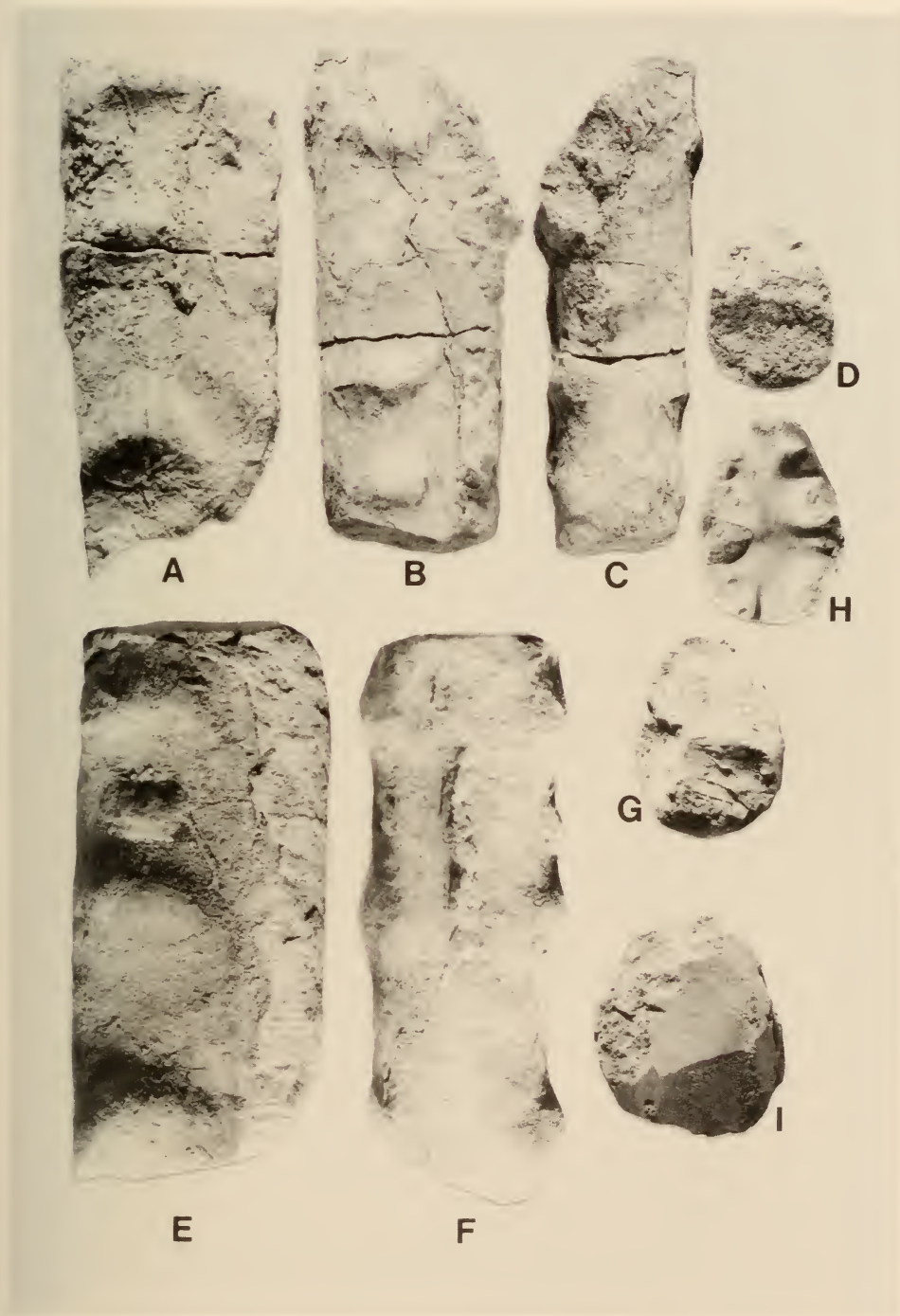


Fig. 119

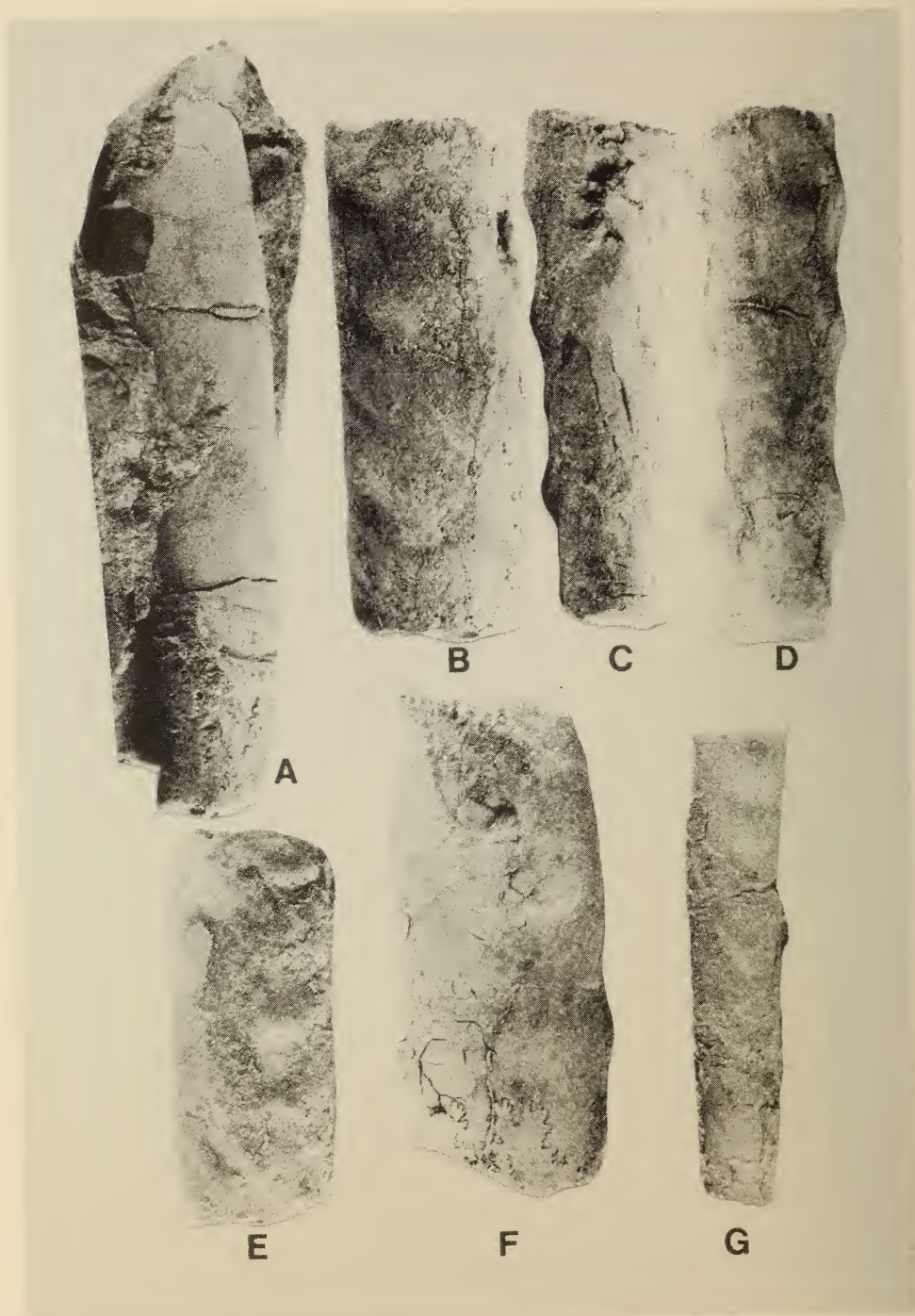


Fig. 120

Lateral ornament consists of crescentic ribs of variable strength, which cover the dorsal two thirds of the flanks—occurring at a frequency of 2–3 per whorl height. In some, e.g. PCZ7630 (Fig. 120A) and PCZ7701, the flanks are virtually smooth; in others, e.g. PCZ7702 (Fig. 119A), the ribs are quite prominent. In the latter, the costal whorl section is conspicuously trigonal to cuneate. In some specimens the venter appears to be slightly undulating.

The aperture is preserved in PCZ9150e (Fig. 117C–D). The dorsal rostrum is short, and the ventral rostrum only a little longer, and distinctly spoon-shaped.

The suture is only partially exposed in a few specimens, e.g. PCZ9150h and PCZ7630 (Fig. 118A). It shows narrow lateral saddles and a splayed lateral lobe (L).

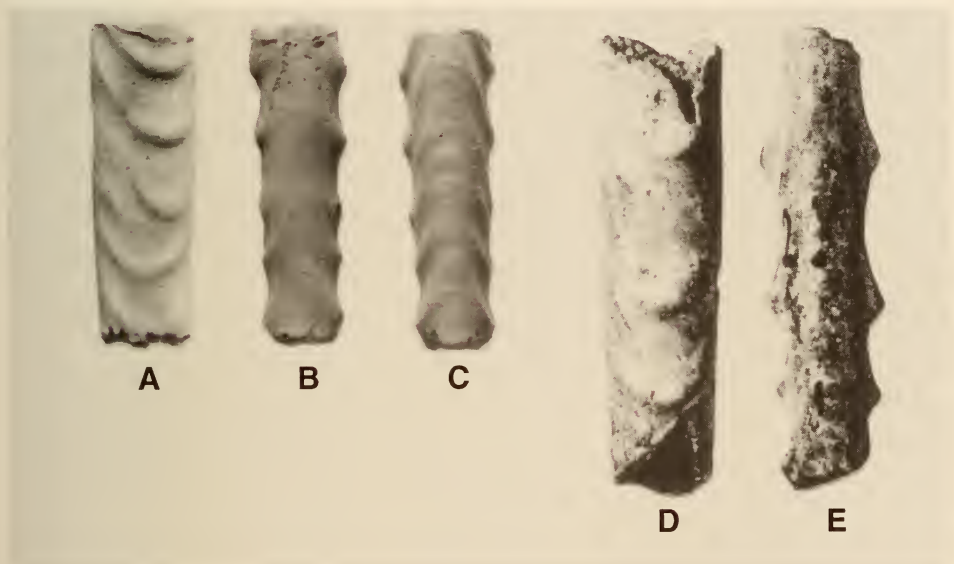


Fig. 121. A–C. *Baculites* sp. (?nov.) cf. *B. aquilaensis* Reeside. Plaster cast of GD12358, the original of Collignon (1970, pl. 639 (fig. 2358)), from the Upper Campanian, zone of *Hoplitoplacenticerus marroti* of gisement 227–2, Mokotibe (Antsalova), Madagascar. D–E. *Baculites bassei* Besairie, 1930. Copy of the lectotype illustrated in Besairie (1930, pl. 22 (fig. 8–8a)), from the Upper Campanian or Lower Maastrichtian, of north of Trangahy, Madagascar. Both $\times 1$.

Discussion

The subtrigonal whorl section clearly distinguishes *B. nibelae* from *B. vanhoepeni*, the latter having a typically elliptical whorl section. The shape of the lateral ribs in both species is similar but those of *B. vanhoepeni* are much more robust, and the latter species grows to a much larger size than *B. nibelae*. The occurrence of *B. nibelae* at locality 111, east of 110, suggests that it is younger than *B. vanhoepeni*, but still in the Campanian.

The subtrigonal whorl section of *B. nibelae* places this species close to the group of baculitids described by Collignon (1970) from the lower part of the Middle Campanian of Madagascar. The closest match is probably *B. rectangularis* Collignon (1970: 12, pl. 611 (figs 2279–2281)) (herein Fig. 87), but the whorl section of *B. nibelae* is more prominently triangular and, in typical forms, it has stronger lateral ornament.

The specimen described by Collignon (1970: 13, pl. 612 (fig. 2285)) from the upper part of the Middle Campanian of Madagascar as *Baculites* cf. *taylorensis* is probably the same as *B. nibelae*. *Baculites* sp. (nov.?) cf. *B. aquilaensis* in Collignon (1970: 81, pl. 639 (fig. 2358)) (Fig. 121A–C) from the Upper Campanian of Madagascar has stronger ornament than any of our *B. nibelae*, but the whorl section suggests that it is closely allied. *Baculites bassei* Besairie (1930: 222, pl. 22 (fig. 8, 8a)) (herein Fig. 121D–E), from the Upper Campanian or Lower Maastrichtian of north of Trangahy (Maintirano) in Madagascar, is known from a single specimen only. It is also very similar to *B. nibelae*. Given more and precisely located material from Madagascar, *B. bassei* may prove to be a senior synonym of *B. nibelae*.

The Campanian baculitid from Andimaka described by Collignon (1938) as *B. aspero-anceps* (Collignon 1938: 89, pl. 6 (fig. 7)), also has a trigonal whorl section similar to that of *B. nibelae*, and may belong to this species.

In terms of lateral ornament and to a lesser extent, the whorl section, *B. nibelae* is similar to *B. subanceps* Haughton (Figs 130, 131A–H) (see also Howarth 1965: 368, pl. 5 (fig. 3), pl. 6 (figs 6–7), pl. 7 (fig. 1), text-figs 4, 13–15). In the latter species, however, the venter tends to become flat and, in some specimens, even forms an incipient tabulate ventral keel as in typical *Eubaculites*.

The whorl section and ornament of *B. nibelae* are very similar to those of *Eubaculites labyrinthicus* (Morton), recorded from the Lower Maastrichtian of Madagascar by Collignon (1971: 18, pl. 646 (fig. 2395)) (as *Eubaculites otacodensis* Stol.). As yet undescribed baculitids from the Upper Campanian of Israel, with even more angular trigonal whorl section and prominent lateral ribbing, are even closer to *E. labyrinthicus*. *Baculites lomaensis* Anderson (1958: 191, pl. 48 (figs 5, 5a–6)) (see also Matsumoto 1959: 126, pl. 34 (figs 1a–c, 2a–c), text-figs 35–38, 39–41), from the Lower Maastrichtian of California, has a similar trigonal whorl section, but apparently weaker dorsolateral bullae. We doubt if *B. nibelae*, *B. lomaensis* and the Israeli baculitids are ancestral to *E. labyrinthicus*, but the style of ornament and whorl section are remarkably similar.

The evolution of baculitids with a trigonal whorl section, as in *E. labyrinthicus*, appears to be a wide-spread feature near the Campanian–Maastrichtian boundary, as already noticed by Lewy (1986: 5) (see also Klinger & Kennedy in press).

Fig. 122 (see facing page). *Baculites duharti* Hünicken, 1975. A–D. SAM-7683 from locality 109H, Zululand, St Lucia Formation, Campanian II. E–G. SAM-PCZ9873a from locality 110, Zululand, St Lucia Formation, Campanian II.

A, E–G $\times 1$; B–D $\times 0.75$.

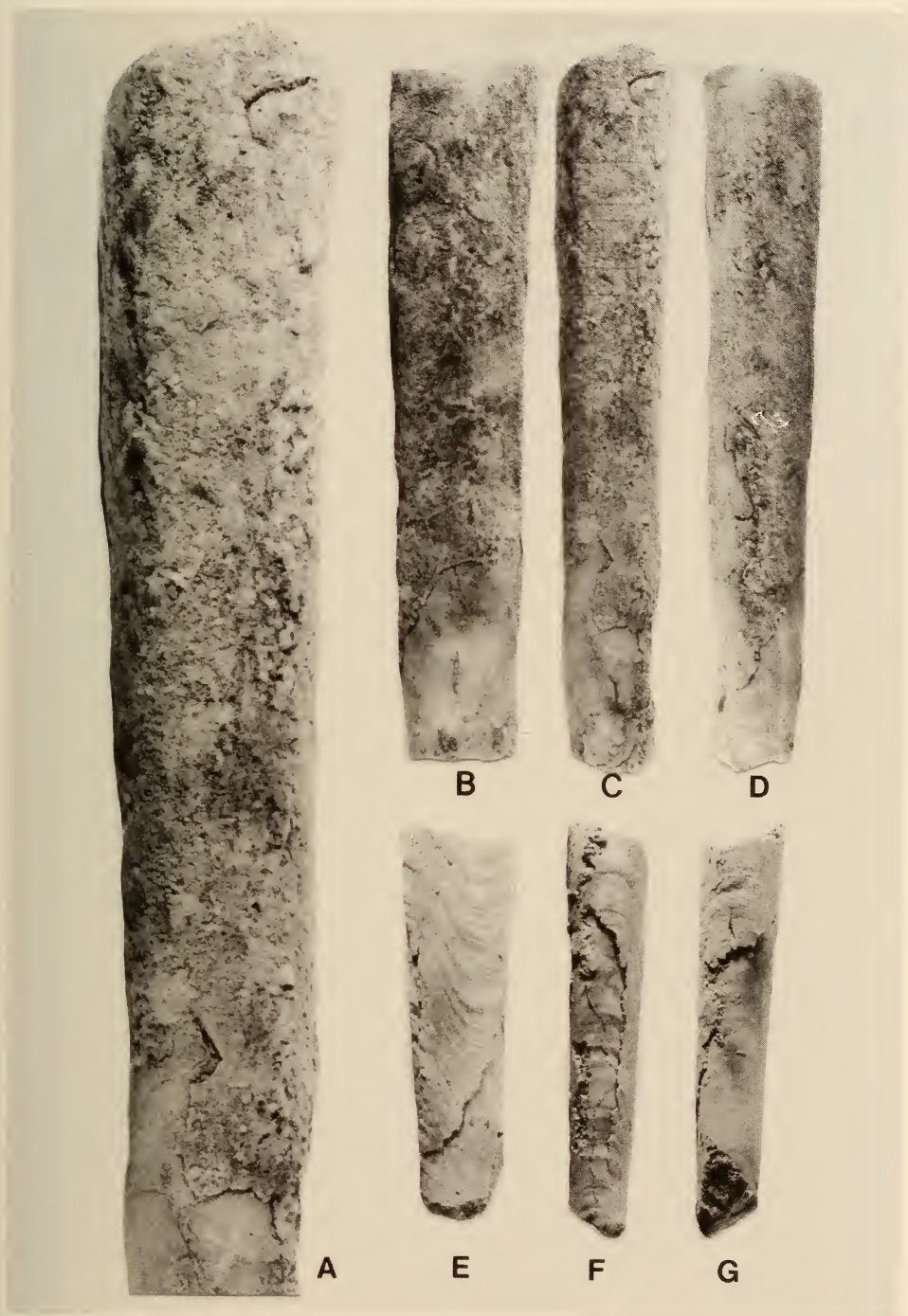


Fig. 122

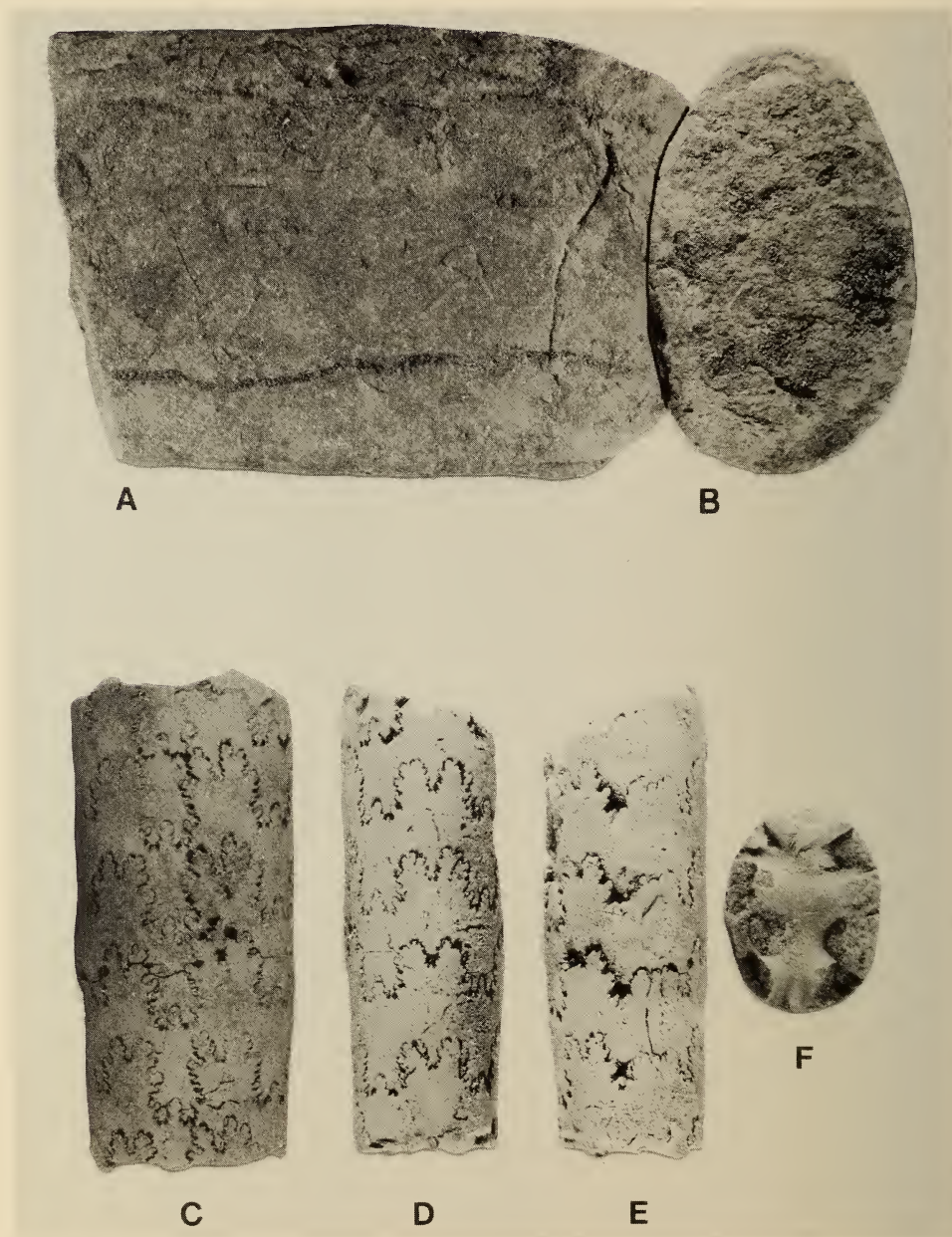


Fig. 123. *Baculites duharti* Hünicken, 1975. A-B. SAM-PCZ7703a. C-F. SAM-PCZ7685, both from locality 109G, Zululand, St Lucia Formation, Campanian II. Both $\times 1$.

Fig. 124 (see facing page). *Baculites duharti* Hünicken, 1975. Concretion, SAM-PCZ9873, from base of cliff at locality 110, Zululand, St Lucia Formation, Campanian II. All $\times 1$.



Fig. 124

Occurrence

Campanian III of Zululand.

Baculites duharti Hünicken, 1975

Figs 122–127

- 1975 *Baculites duharti* Hünicken, in Hünicken *et al.* 1975, p. 116, pl. 1 (figs 1–4), pl. 2 (figs 1–2), pl. 3 (figs 5–8), text-figs 2a–d, 3a–c, 4–5.
 1980 *Baculites duharti* Hünicken; Hünicken, Charrier & Lahsen, p. 224, pl. 1 (figs 1a–b, 2), pl. 2 (figs 1a–c, 2, 3a–b, 4–5, 6a–b), text-figs 3–9.

Type

Holotype is the specimen figured by Hünicken (in Hünicken *et al.* 1975, pl. 1 (figs 1–4), text-figs 2c–d, 4a) from the Middle and/or Upper Campanian of Member 'e' of the Cerro Matero Formation, at Rio Sur, Tierra del Fuego, Chile, CPC D1127.

Material

More than 100 specimens from a single concretion, SAM-PCZ9873, 9873a–v, found at the base of the section at locality 110, Nibela Peninsula, Zululand, St Lucia Formation, Campanian III; SAM-PCZ7683, 7685, and 7703, from locality 109G; and SAM-PCZ7689 from locality 109H, Nibela Peninsula, Zululand (Fig. 90), St Lucia Formation, Campanian II.

Dimensions

<i>Spec.</i>	<i>MxWb</i>	<i>MxWh</i>	<i>Wb/Wh</i>	<i>MnWb</i>	<i>MnWh</i>	<i>Wb/Wh</i>	<i>D</i>	<i>Ti</i>
PCZ9873a	12.0	17.0	0.71	8.6	12.0	0.72	48	10.4
PCZ7689	22.0	31.0	0.71	21.0	28.0	0.75	64	4.69
PCZ7685	22.0	29.0	0.76	20.0	26.0	0.77	57	5.26
PCZ7683	34.0	43.0	0.79	23.5	31.0	0.76	200	6.0
PCZ7703	35.0	58.0	0.60	—	—	—	—	—

Description

A large concretion from the base of the section at locality 110 is crammed with more than 100 specimens of a smooth baculitid (Figs 124–126), differing markedly from the heavily ornamented *B. vanhoepeni* from the higher parts of the section. Four other smooth baculitids from the south-western part of the Nibela Peninsula at localities 109G and 109H (Figs 122A–D, 123A–F) are much larger than those from locality 110, but we assume they belong to the same species—being of more or less the same age.

Fig. 125 (*see facing page*). *Baculites duharti* Hünicken, 1975. Concretion, SAM-PCZ9873, from the base of cliff at locality 110, Zululand, St Lucia Formation, Campanian II.
 Note slight wavy venter on top right. $\times 1$.



Fig. 125



Fig. 126. *Baculites duharti* Hünicken, 1975. Concretion, SAM-PCZ9873, from base of cliff at locality 110, Zululand, St Lucia Formation, Campanian II.
Note wavy venter at top left. $\times 1$.

The whorl section (Figs 123B, F, 127) is distinctly elliptical, to ovoid, with the venter only very little narrower than the dorsum. Lateral ornament consists of very fine striae only, but in some specimens, e.g. PCZ9873a (Fig. 122E-G), low, fold-like ribs develop over the ventral half of the flanks. In some of the larger specimens, where the shell is preserved (Figs 125, 126), the venter is ornamented with scale-like undulations.

A slight constriction is visible on the venter of SAM-PCZ7685 (Fig. 123C-F). The species grows to a large size—the maximum whorl height measured is 60 mm (Fig. 123A-B). The suture is finely incised with open saddles and lobes (Fig. 127A-C).

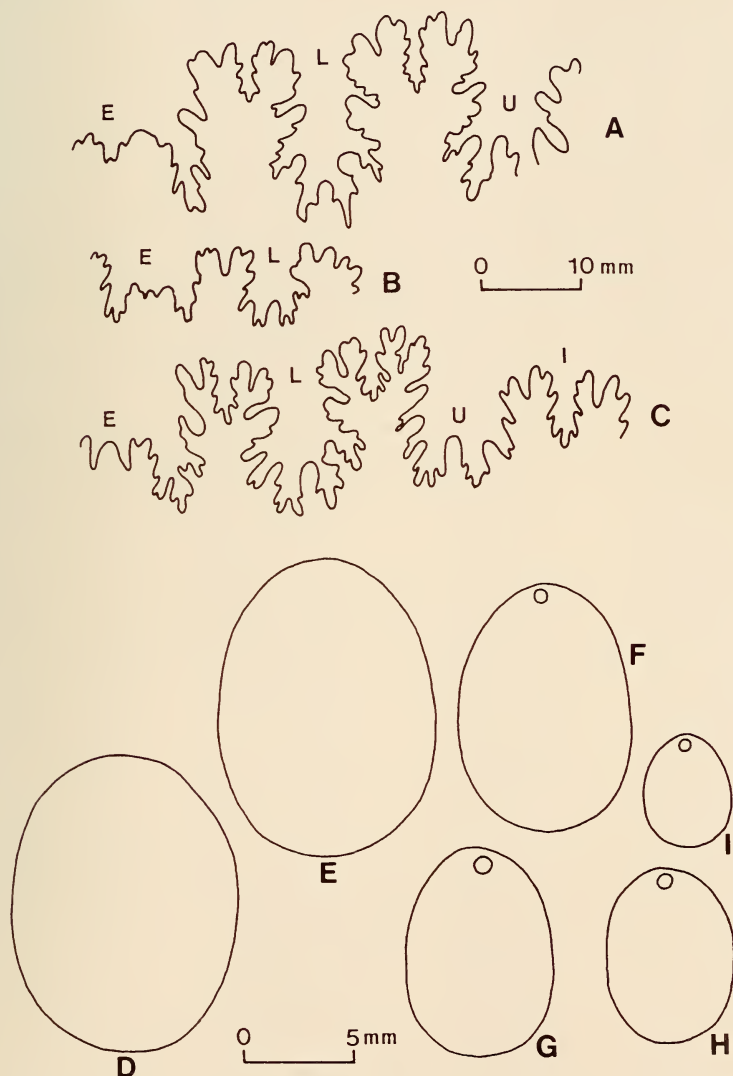


Fig. 127. *Baculites duharti* Hünicken, 1975. Suture lines and whorl sections. Venter facing upwards. Scale bar for size.

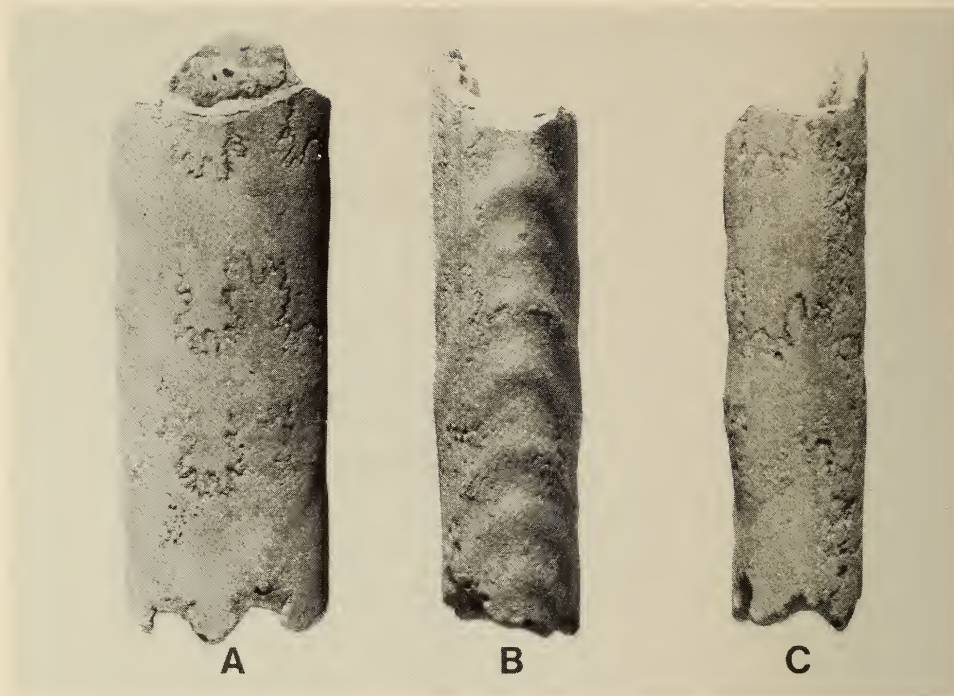


Fig. 128. *Baculites ambatryensis* Collignon, 1971. Plaster cast of the holotype, GD12392, the original of Collignon (1971, pl. 645 (fig. 2392)) from the Lower Maastrichtian of gisement 400, Cote d'Ambatry (Betioky), Madagascar. All $\times 1$.

Discussion

The elliptical whorl section and relatively simple suture show that this baculitid belongs to the group of *B. vanhoepeni*. However, the total absence of lateral ornament in more than a hundred specimens clearly shows that this is indeed a consistently smooth baculitid species and not merely a smooth variant of *B. vanhoepeni*.

As discussed above, identifying or separating smooth *Baculites* species is very difficult unless the whorl section and sutures are very distinctive, or if the exact age is known.

The closest match we could find both in morphology and age is *B. duharti* first described from Tierra del Fuego by Hünicken (in Hünicken *et al.* 1975: 116, pl. 1 (figs 1-4), pl. 2 (figs 1-2), pl. 3 (figs 5-8), text-figs 2a-d, 3a-c), 4-5) and imprecisely dated as Campanian-Maastrichtian. Later, Hünicken *et al.* (1980: 224, pl. 1 (figs 1a-b, 2), pl. 2 (figs 1a-c, 2, 3a-b, 4-5, 6a-b),

Fig. 129 (see facing page). *Baculites asperoanceps* Lasswitz, 1904. Plaster cast of the lectotype, nr 3045 s (k), MGUWr, from Austin, Texas, in the collections of the Henryk Teisseyre Geological Museum of the Institute of Geological Sciences of the University of Wrocław. $\times 1$.

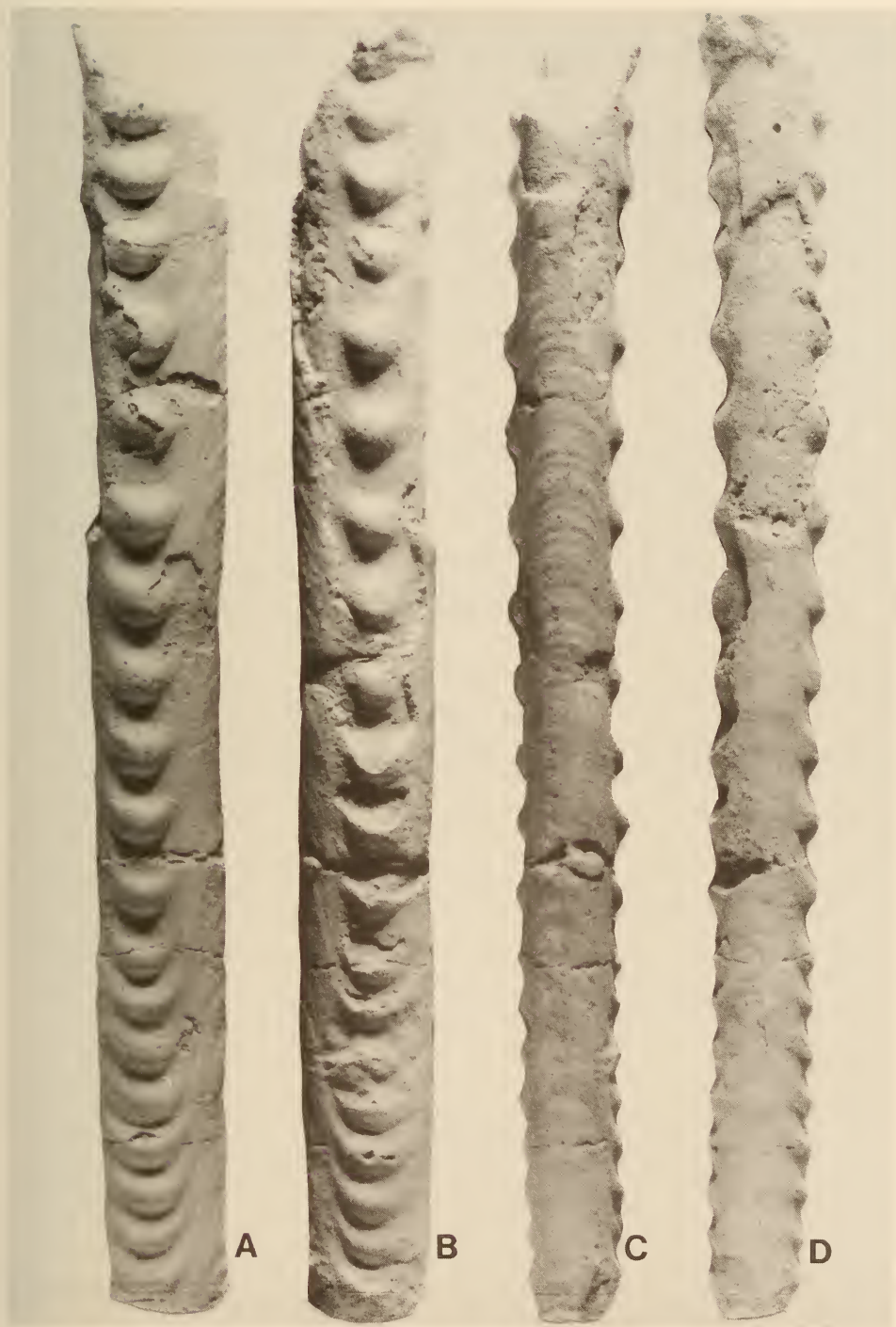


Fig. 129

text-figs 3-9) described additional material, also from Tierra del Fuego, but more precisely dated as Middle to Late Campanian. The drawings of the suture lines by Hünicken *et al.* (1980, text-figs 3-9) show a suture more complex and phylloid than ours, but photographs of the sutures (e.g. their pl. 2 (figs 3-6)) are much simpler and comparable to the Zululand material. From a palaeobiogeographical point of view, the record of *B. duharti* from Zululand also is acceptable.

Baculites duharti differs from the older *B. bailyi* mainly in being much larger and having a predominantly elliptical, rather than ovoid, whorl section. We do not think that *B. duharti* is derived from the *B. bailyi* lineage; instead we regard it as a smooth offshoot of the *B. capensis*-*B. vanhoepeni* lineage.

Baculites duharti clearly differs from *B. rectus* in having a much simpler suture.

The only Middle Campanian Madagascan baculitid species with which *B. duharti* could possibly be compared, is *B. ankilizatensis* (Collignon 1970: 13, pl. 612 (figs 2282-2284)) (herein Fig. 89), especially as far as maximum size is concerned. However, some specimens of *B. ankilizatensis* show distinct, albeit low, lateral ornament.

Some specimens of *B. subanceps* in the collections of the South African Museum, e.g. SAM-6829a (Figs 130D-F) are indistinguishable from *B. duharti*, but this species includes forms with distinct lateral ornament, and the whorl section is quite distinctive in some specimens, tending to form a tabulate ventral keel.

Our material also resembles *Baculites* smooth species of Cobban (1962: 714, pl. 108 (figs 1-4), text-figs 1i-j) from the Middle Campanian of eastern Wyoming. This species was renamed *B. cobbani* by Khakimov (in Atabekian & Khakimov 1976: 98, pl. 11 (figs 2-7)) for material from the Lower Campanian of Central Asia.

The largest of our specimens (Fig. 123A-B) is superficially similar to *B. knorrianus* Desmarest, 1817 (recently reviewed by Kennedy & Summesberger 1987: 32, pl. 4 (figs 4-6), pl. 5 (figs 1-14), text-fig. 2; Birkelund 1993: 52, pl. 13 (figs 12-14) and Kennedy 1993: 109, pl. 5 (figs 13-22), pl. 6 (figs 11-13, 18-23), text-fig. 5a-c). However, *B. knorrianus* is restricted to the Lower Maastrichtian, and has a far more compressed whorl section and a more complex suture line.

Fig. 130 (*see facing page*). *Baculites subanceps* Haughton, 1925. A-C. SAM-6824, the lectotype. D-F. SAM-6829a. G. SAM-6829b. All from the Upper Campanian-Lower Maastrichtian of Carimba, Angola.

Fig. 131 (*see overleaf*). A-H. *Baculites subanceps* Haughton, 1925. A-C. SAM-6829c. D-G. SAM-6829d. H. SAM-6829e. All from the Upper Campanian-Lower Maastrichtian of Carimba, Angola.

I-M. *Baculites anceps* Lamarck, 1822. I-K. SAM-6145b. L. SAM-6145c. M. SAM-6748, from the ?Lower Maastrichtian east of Capolo. N-R. *Baculites* sp. from the uppermost Turonian or basal Coniacian at Mossamedes, Angola. The oldest tuberculate baculite. Unregistered specimens from Cooper collection, SAM.

A-C, G, I-R $\times 1$; D-F $\times 0.5$.

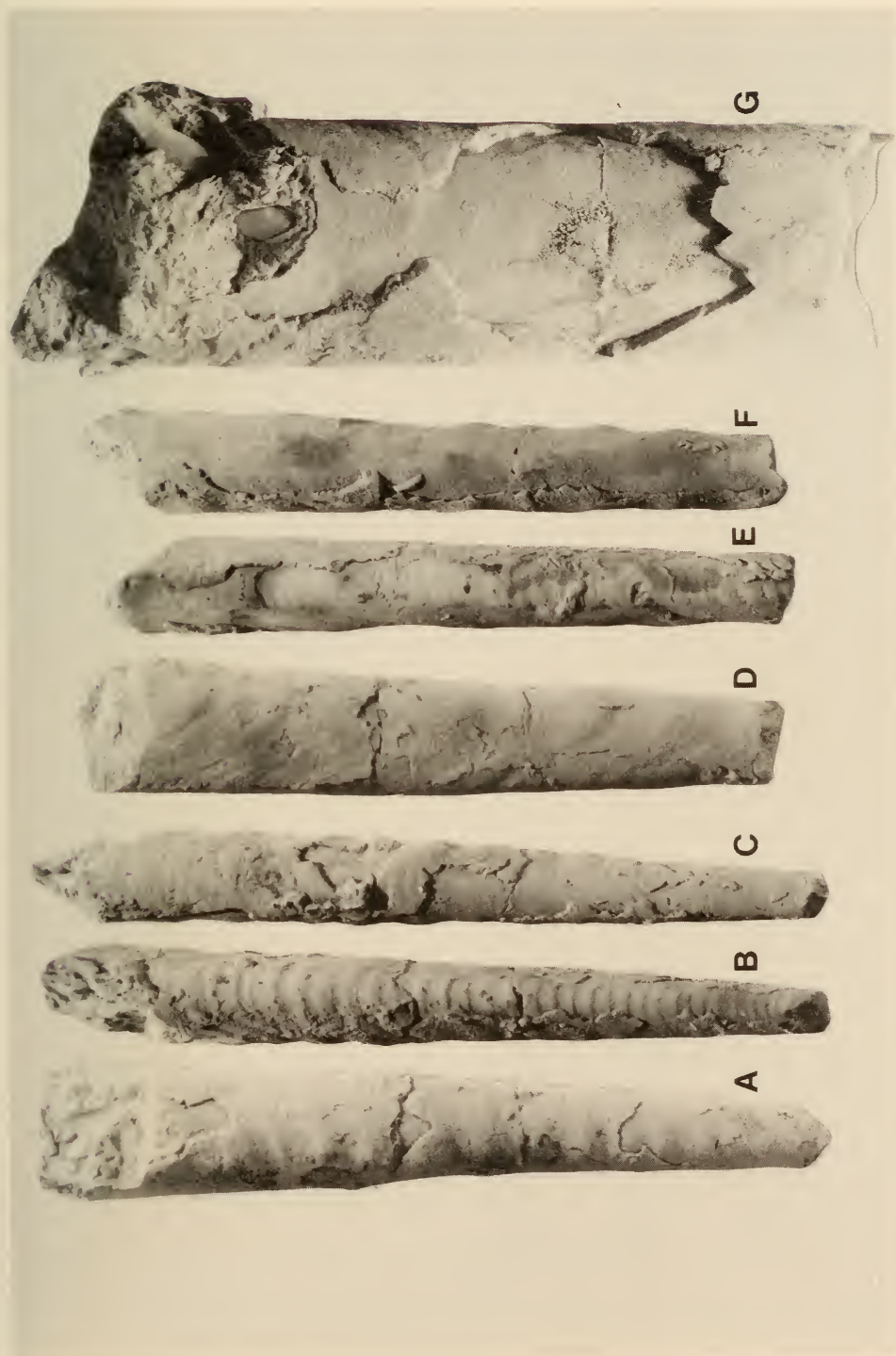


Fig. 130

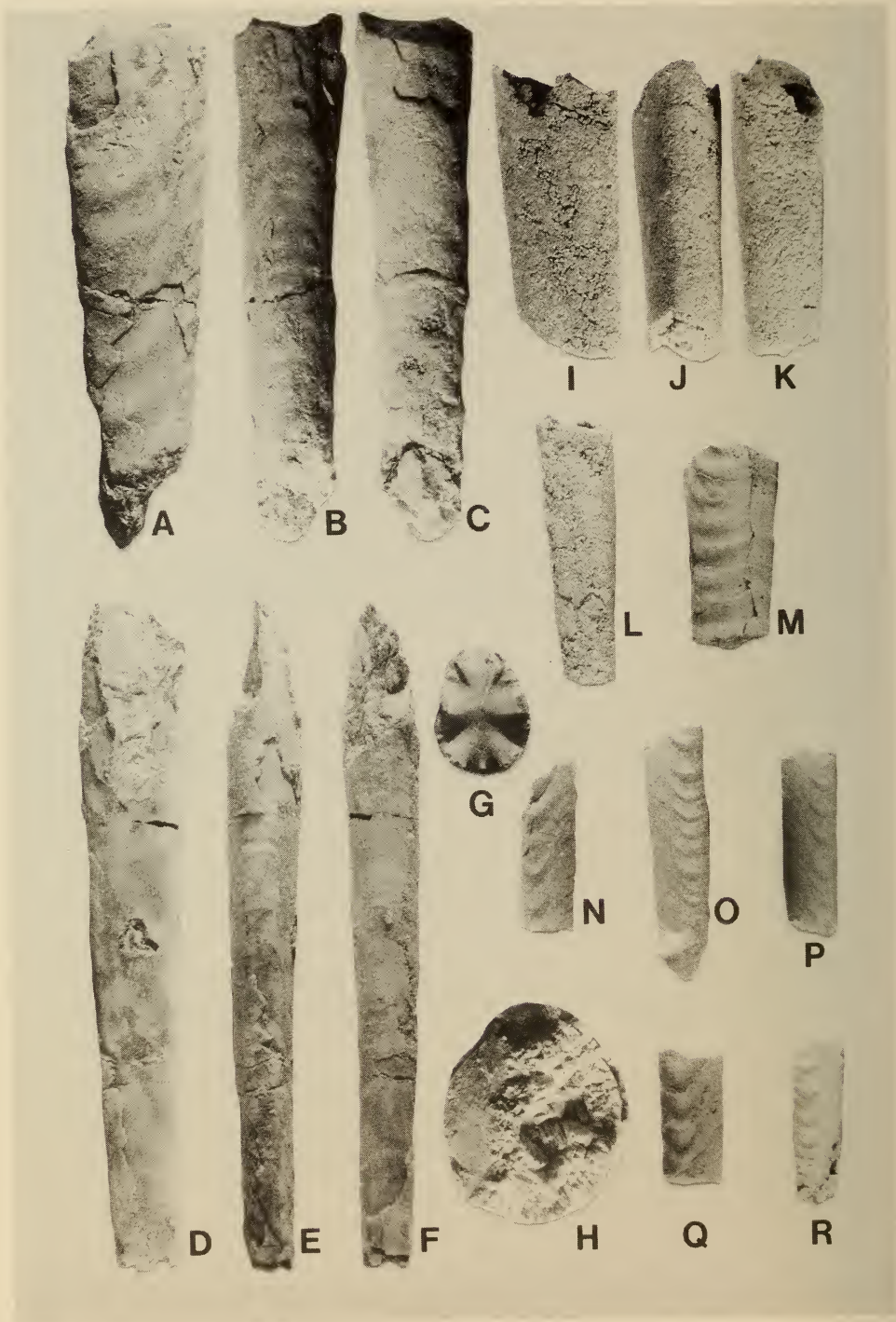


Fig. 131

Baculites ambatryensis Collignon (1971: 14, pl. 645 (fig. 2392)) (herein Fig. 128) from the Lower Maastrichtian of Madagascar is also superficially similar, but has a more compressed whorl section at comparable diameters (Wb : Wh 19.5 : 29), and coarse corrugations over the venter.

Baculites eliasi Cobban (1958: 663, pl. 91 (figs 1-11), text-figs 1f-g, i-j) from the Lower Maastrichtian of the U.S. Western Interior also has a more complex suture with a constricted lateral lobe (L).



Fig. 132. *Baculites* sp. from the uppermost Turonian or basal Coniacian at Mossamedes, Angola. The oldest tuberculate baculite. Cooper Collection, S.A. Museum.

A. SAM-1742. B-D. SAM-1743. E. SAM-1733. F. SAM-1745.

All $\times 1$.

Baculites fuchsi Redtenbacher (1873: 134, pl. 30 (fig. 15)) is difficult to interpret (see above, p. 47) but it is older, Santonian, being associated with *B. incurvatus*.

Baculites inornatus Meek (1862: 316) (see especially Matsumoto 1959: 155, pl. 38 (fig. 1a-c), pl. 43 (fig. 5a-c), text-figs 72a-b, 73a-d, 74-79; Ward 1978: 1151, pl. 1 (figs 1-2), text-fig. 5) is a predominantly smooth species from the Lower Campanian of California, British Columbia and Hokkaido. Records of *B. inornatus* from the Coniacian of Venezuela by Renz (1982: 105, pl. 34 (figs 3-4, 5a-b, 6), text-fig. 80) are obvious misidentifications. The suture of *B. inornatus* is complex, with phylloid folioles, clearly differing from our material.

Baculites kotanii Matsumoto *et al.* (1980: 408, figs 1-2) from the Upper Campanian of Shikoku, Japan, is nearly smooth, with only faint subcostae on the flanks. Again, the suture appears to be more complex with narrower saddles and lobes than the Zululand material.

Baculites vertebralis Lamarck, 1801, is a compressed, smooth species from the Upper Maastrichtian of Europe and North Africa, and resembles our largest specimen. Age difference apart, it also has a far more complex suture line (see e.g. Kennedy 1986a, text-fig. 7D-E).

Occurrence

Middle and/or Upper Campanian of Tierra del Fuego, and Campanian III of Zululand.

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APPENDIX

List of material and dimensions of *Baculites bailyi*, *Baculites capensis*, and *Baculites vanhoepeni*.*Baculites bailyi*

Specimen	MxWb	MxWh	Wb/Wh	MnWb	MnWh	Wb/Wh	D	Ti
PCP6769	4.8	6.4	0.75	3.6	5.2	0.69	21	5.7
PCZ8390i	4.8	6.5	0.74	4.0	5.5	0.73	20.5	4.9
PCP6766	6.0	8.0	0.75	5.0	6.5	0.77	17	8.8
D108	6.2	8.9	0.7	—	—	—	—	—
PCZ8390j	6.7	9.0	0.74	—	—	—	—	—
PCZ8366a	6.8	9.5	0.72	5.5	7.0	0.79	30	8.3
PCZ8390a	7.0	9.3	0.75	4.8	6.6	0.73	38	7.1
PCZ8344	7.0	9.0	0.78	4.4	6.0	0.73	60	5.0
PCZ8355	7.0	9.0	0.78	5.4	7.4	0.73	20	8.0
PCZ8352	7.2	9.7	0.74	5.5	7.8	0.71	28	6.8
PCZ8354	7.4	9.5	0.78	6.6	8.6	0.76	21	4.3
SAM-4822	7.6	8.7	0.87	6.6	6.6	1.0	42	2.6
PCZ8367	8.0	10.8	0.74	8.0	10.0	0.8	35	2.3
PCZ8360	8.0	10.6	0.76	6.3	8.9	0.71	34	5.0
PCZ8016	8.6	11.4	0.75	7.8	10.6	0.74	20	4.0
PCZ8359	9.0	14.0	0.64	8.0	12.0	0.67	39	5.1
PCZ8375	9.2	12.6	0.73	—	—	—	—	—
PCZ8374	9.2	12.1	0.76	8.6	11.2	0.77	28	3.2
PCZ8020	10.0	14.0	0.71	9.0	12.7	0.71	28	4.6
PCZ8370	10.3	13.6	0.76	—	—	—	—	—
PCZ8387	10.8	13.2	0.82	9.3	11.6	0.80	43	3.7
PCZ8373	11.0	15.0	0.73	—	—	—	—	—

Baculites bailyi (cont.)

Specimen	MxWb	MxWh	Wb/Wh	MnWb	MnWh	Wb/Wh	D	Ti
PCZ8349	11.6	15.0	0.77	—	—	—	—	—
PCZ8347	11.7	14.2	0.82	10.6	13.4	0.79	25	3.2
PCZ9940	12.0	15.0	0.8	12.3	15.0	0.82	42	0
PCZ8369	12.5	16.3	0.77	9.7	13.8	0.70	64	3.9
PCZ8346	13.0	17.0	0.76	11.0	14.0	0.79	44	6.8
PCZ8371	13.0	16.0	0.81	11.6	15.3	0.76	40	1.7
PCZ8345	13.0	17.0	0.76	11.3	14.8	0.76	51	4.3
PCZ8366b	15.5	20.5	0.76	—	—	—	—	—
PCZ9952	15.6	21.0	0.74	14.4	20.7	0.70	44	0.9
PCZ9945	17.0	21.0	0.81	—	—	—	—	—

Baculites capensis

Specimen	MxWb	MxWh	Wb/Wh	MnWb	MnWh	Wb/Wh	D	Ti	Tu/Wb
D1124/8	4.4	7.0	0.63	3.3	5.5	0.6	20	7.5	2
H200/15	6.0	9.0	0.67	5.0	7.0	0.71	25	8.0	2
H149/19	6.2	8.0	0.77	4.5	6.4	0.70	24	6.67	3
D1124/7	6.7	9.5	0.70	5.3	7.0	0.76	24	10.4	—
H200/61	7.0	9.0	0.78	5.4	7.4	0.73	25	6.4	3
H200/29	7.0	9.0	0.78	6.0	8.0	0.75	22	4.5	4

Baculites capensis (cont.)

Specimen	MxWb	MxWh	Wb/Wh	MnWb	MnWh	Wb/Wh	D	Ti	Tu/Wb
H200/47	7.0	10.0	0.7	6.0	8.4	0.71	23	6.96	3
D1124/4	7.0	10.0	0.7	5.0	7.0	0.71	47	6.38	3
H200/59	7.2	10.4	0.69	7.0	9.0	0.78	20	7.0	3-4
H203/48	7.3	10.6	0.69	7.0	9.0	0.78	15	10.7	3
H201/13a	7.4	10.0	0.74	5.7	7.7	0.74	20	11.5	2
H200/70	7.4	9.0	0.82	6.0	7.0	0.86	27	7.4	2.5
H200/62	7.4	9.6	0.77	5.4	7.2	0.75	29	8.28	3
H203/1	7.5	11.6	0.65	6.5	8.0	0.81	34	10.6	2.5
D1124/2	7.5	10.8	0.69	5.5	8.0	0.68	36	7.78	3-4
H201/17	8.0	11.0	0.73	6.6	8.7	0.76	30	7.67	2
H200/51	8.0	10.3	0.78	6.3	8.6	0.73	34	5.0	2.5
H200/25	8.0	12.0	0.67	8.0	12.0	0.67	28	0	2.5-3
D1028/21	8.0	10.0	0.8	7.0	9.0	0.78	21	4.76	2
D1124/4	8.0	13.0	0.61	7.7	10.0	0.77	28	10.7	2
PCZ8351b	8.4	11.3	0.74	7.6	10.0	0.76	28	4.56	—
H201/25	9.0	13.0	0.69	8.0	12.0	0.67	28	3.57	2
H200/39	9.0	13.0	0.69	8.0	11.4	0.70	34	4.7	2.5-3
H200/57	9.0	12.0	0.75	7.7	10.8	0.73	22	5.45	2.5
PCZ8034	9.0	13.0	0.69	8.4	10.6	0.79	27	8.89	2
H1B/12	9.0	12.0	0.75	7.7	10.5	0.73	37	4.05	2.5
H148/3a	9.0	13.0	0.69	7.0	9.6	0.73	47	7.23	3
H200/44	9.3	13.0	0.72	7.0	10.0	0.7	30	10.0	2.5
H149/16	9.3	14.4	0.65	8.6	13.0	0.66	33	4.24	2
D1028/4	9.5	13.0	0.73	8.0	12.0	0.67	38	2.63	2
PCP8054	9.5	13.0	0.73	—	—	—	—	—	2.5
H200/56	9.6	13.4	0.72	—	—	—	—	—	—

Baculites capensis (cont.)

Specimen	MxWb	MxWh	Wb/Wh	MnWb	MnWh	Wb/Wh	D	Ti	Tu/Wb
D1124/5	9.6	13.0	0.74	9.2	12.0	0.77	28	3.57	2
H202/11	9.8	12.5	0.78	9.0	12.0	0.75	29	1.72	2-2.5
H202/7a	10.0	14.8	0.68	10.0	13.0	0.77	39	4.6	2.5
SAM-4823	10.0	14.0	0.71	8.7	13.0	0.66	23	4.3	2
D66	10.0	14.5	0.69	7.4	13.0	0.57	35	4.3	1.5-2
PCP8241	10.0	13.0	0.77	9.0	12.4	0.73	20	3.0	0
PCP8662	10.0	13.8	0.77	9.0	12.4	0.73	21	6.7	2.5-3
PCP8663	10.0	14.0	0.71	8.0	12.0	0.67	30	6.7	2
PCP8664	10.0	13.3	0.75	8.6	13.0	0.66	28	1.07	2
H205/12	10.0	14.0	0.71	10.0	14.0	0.70	24	0	3.5
H203/46	10.0	13.5	0.74	10.0	13.0	0.77	23	2.2	—
H201/23	10.0	13.7	0.73	9.0	12.7	0.71	25	4.0	2
H201/19	10.0	14.0	0.71	9.0	13.0	0.69	25	4.0	2
H200/53	10.0	12.0	0.83	8.8	12.0	0.73	19	0	4
H200/101	10.0	14.0	0.71	7.6	13.2	0.58	25	3.2	3
H200/40	10.0	14.0	0.71	9.0	13.0	0.69	21	4.76	2.5
D1028	10.0	15.0	0.67	9.0	14.0	0.64	35	2.86	3
KK72a	10.0	14.0	0.71	8.0	13.0	0.61	37	2.70	1
PCZ8039	10.0	13.0	0.76	—	—	—	—	—	—
H1B/23	10.0	13.5	0.74	7.5	12.0	0.62	42	3.57	—
D1124/1	10.0	15.0	0.67	9.0	14.0	0.64	33	3.03	2
D1124/3	10.0	14.0	0.71	9.6	12.4	0.77	26	6.15	2.5
H200/99	10.5	14.3	0.73	—	—	—	—	—	—
H203/6	11.0	15.0	0.73	9.5	14.5	0.65	32	1.56	2.5-3
H202/7	10.6	13.6	0.78	9.2	11.4	0.81	29	7.59	3
H200/55	11.0	15.0	0.73	10.0	14.0	0.71	31	3.2	2

Baculites capensis (cont.)

Specimen	MxWb	MxWh	Wb/Wh	MnWb	MnWh	Wb/Wh	D	Ti	Tu/Wb
H200/16	11.0	14.0	0.79	—	—	—	—	—	—
H200/102	11.0	17.0	0.65	9.8	14.5	0.68	27	9.26	3
D1028/16	11.0	15.0	0.73	9.0	13.0	0.69	36	5.56	2
S541	11.0	15.0	0.73	9.5	14.0	0.68	43	2.32	2
PCZ8036	11.0	15.0	0.77	—	—	—	—	—	—
H1B/24	11.0	15.0	0.73	8.8	13.0	0.68	39	5.12	3
H1B/13	11.0	15.0	0.73	10.0	14.0	0.71	28	3.57	3
Z632e	11.0	15.0	0.73	10.0	14.0	0.71	25	4.0	2
H148/3b	11.0	15.4	0.71	10.0	13.4	0.75	50	4.0	—
D1028/10	11.6	17.0	0.68	—	—	—	—	—	—
H200/09	11.7	15.0	0.78	11.0	14.7	0.75	35	0.86	3-3.5
H204/1	12.0-	16.0	0.75	12.0	15.0	0.8	24	4.2	2.5
H201/10	12.0	16.0	0.75	11.0	15.0	0.73	35	2.86	2
H201/7	12.0	17.0	0.71	11.0	16.5	0.67	35	1.43	2
H200/13	12.0	18.0	0.67	12.0	17.5	0.69	31	1.61	2-2.5
H200/36	12.0	15.0	0.8	11.0	15.0	0.73	28	0	2.5
H201/12b	12.0	16.0	0.75	—	—	—	—	—	—
D1028/12	12.0	16.0	0.75	10.0	13.0	0.77	55	5.45	2
D1028/a	12.0	16.0	0.75	10.0	14.0	0.71	44	4.54	2
A361	12.0	17.0	0.71	12.0	16.0	0.75	55	1.82	3
PCZ8032	12.0	17.0	0.71	11.0	15.0	0.73	29	6.90	1
D1028/18	12.0	16.0	0.75	—	—	—	—	—	—
D1052	12.0	15.0	0.8	9.0	12.0	0.75	50	6.0	—
D1124a	12.0	17.0	0.71	11.5	16.3	0.71	37	1.89	2
H25/6	12.0	17.0	0.71	10.0	14.0	0.71	33	9.09	2.5
A606	12.5	15.0	0.83	11.0	14.0	0.79	33	3.03	1.5-2

Baculites capensis (cont.)

Specimen	MxWb	MxWh	Wb/Wh	MnWb	MnWh	Wb/Wh	D	Ti	Tu/Wb
H203/4	12.5	15.6	0.80	—	—	—	—	—	—
H201/12a	12.6	18.0	0.70	11.0	15.0	0.73	40	7.5	2.5
PCP8052	12.7	18.0	0.70	—	—	—	—	—	—
H201/9	13.0	17.0	0.76	11.0	15.5	0.71	35	4.29	2
H205/18	13.0	18.0	0.72	—	—	—	—	—	—
H202/5	13.0	16.6	0.79	—	—	—	—	—	—
H201/26	13.0	18.0	0.72	—	—	—	—	—	—
H201/21	13.0	18.0	0.72	—	—	—	—	—	—
PCZ8004	13.0	16.0	0.81	11.0	14.8	0.74	38	3.16	2
H200/14	13.0	17.0	0.77	12.0	16.0	0.75	26	3.84	2
Z1795d	13.0	18.0	0.72	9.0	13.0	0.69	80	6.25	2
Z1795g	13.0	17.0	0.77	11.0	15.0	0.73	46	4.3	2
H1B/6	13.0	17.5	0.74	11.0	15.0	0.73	47	3.19	2.5
H204/3	13.3	18.0	0.74	11.0	16.0	0.69	26	7.7	2
H149/2	13.5	18.2	0.74	13.0	16.0	0.81	72	3.06	2
PCZ8385	14.0	18.0	0.78	12.0	16.5	0.72	44	3.4	—
H201/24	14.0	19.0	0.74	—	—	—	—	—	—
H201/20	14.0	19.0	0.74	—	—	—	—	—	—
H200/79	14.0	18.0	0.78	12.0	17.0	0.71	39	2.56	2
D1028/3	14.0	20.0	0.7	13.0	17.0	0.77	55	5.45	2
Z1795c	14.0	19.0	0.74	11.0	18.0	0.61	60	1.67	2
Z632c	14.0	16.0	0.87	11.0	15.0	0.73	37	2.70	2
H1B/4a	14.0	19.0	0.74	13.0	17.0	0.77	?	—	2
H1B/4b	14.5	19.2	0.75	13.0	17.0	0.76	54	4.07	—
PCZ8035	14.5	18.0	0.81	13.0	16.4	0.79	30	5.33	2
PCZ8027	15.0	18.0	0.83	12.0	16.0	0.75	64	3.12	—

Baculites capensis (cont.)

Specimen	MxWb	MxWh	Wb/Wh	MnWb	MnWh	Wb/Wh	D	Ti	Tu/Wb
H201/15	15.0	19.0	0.79	13.0	16.0	0.81	31	9.68	2
H201/11	15.0	20.0	0.75	14.0	19.0	0.74	43	2.32	2
PCZ8033	15.0	19.0	0.79	11.0	16.0	0.69	69	4.34	2
KK72b	15.0	21.0	0.71	13.3	17.4	0.76	54	6.67	0
Z1795f	15.0	21.0	0.71	13.0	18.0	0.72	53	5.66	2
D1052c	15.0	19.0	0.78	12.0	15.4	0.78	49	7.3	3
H201/13b	15.5	20.0	0.78	14.0	18.0	0.78	54	3.70	2
D1124	15.7	22.8	0.69	14.0	19.0	0.74	34	11.8	0
H205/20	16.5	21.0	0.79	14.0	19.0	0.74	27	7.4	0
D1052/1	16.5	22.7	0.73	13.7	19.6	0.70	87	3.56	—
A353	16.6	22.4	0.74	14.0	18.7	0.75	58	6.38	2
Z1795	17.0	23.0	0.74	13.0	18.0	0.72	90	5.56	2.5
SAM-4825	18.0	23.6	0.76	17.0	20.0	0.85	80	4.5	1.5-2
H200/84	18.0	23.5	0.77	15.0	21.0	0.71	95	1.58	—
PCZ8038	18.0	22.0	0.82	—	—	—	—	—	—
Z632a	18.5	26.0	0.71	15.0	20.0	0.75	80	7.5	2-2.5
Z632b	19.0	26.0	0.73	17.0	24.0	0.71	40	5.0	2.5
H201/43	19.0	28.0	0.68	—	—	—	—	—	—
D1052b	19.0	27.0	0.70	—	—	—	—	—	—
D1028/22	20.0	26.0	0.77	19.0	26.0	0.73	76	0	2
36/3234	20.0	27.0	0.74	—	—	—	—	—	—
H201/38	21.0	26.0	0.80	—	—	—	—	—	—
PCZ7218	21.0	27.0	0.78	—	—	—	—	—	—

Baculites vanhoepeni

Specimen	MxWb	MxWh	Wb/Wh	MnWb	MnWh	Wb/Wh	D	Ti	Tu/Wb
D1467	11.0	20.6	0.53	10.7	17.3	0.62	55	6.0	0.5
PCZ7706	11.5	15.3	0.75	7.0	12.6	0.56	64	4.2	0.75
PCZ7717	12.0	15.8	0.76	10.5	13.3	0.79	33	7.6	0.9
PCZ7707	12.7	17.0	0.75	10.6	15.0	0.71	46	4.3	0.7
87a	13.3	17.6	0.76	9.6	12.8	0.75	88	5.5	1
87b	14.0	20.0	0.7	—	18.0	—	47	4.3	1
PCZ7716	15.0	21.0	0.71	—	—	—	—	—	—
PCZ7705	15.0	19.2	0.78	13.7	18.0	0.76	28	4.3	0
A2029a	15.0	25.0	0.6	14.6	23.5	0.62	55	2.7	1
Z1190a	15.0	20.0	0.75	11.0	15.0	0.73	63	7.9	0.8
PCZ7690	15.6	21.7	0.72	13.6	20.0	0.68	36	4.7	0.6
PCZ7692	17.0	24.0	0.71	—	—	—	—	1	—
PCZ8636	17.0	24.0	0.71	20.0	24.0	0.83	48	0	0.7
A2036	18.0	25.0	0.72	18.0	24.0	0.75	50	2.0	—
A2036a	18.0	24.0	0.75	16.4	22.0	0.74	31	6.5	0.8
PCZ7640	18.0	28.0	0.64	—	—	—	—	—	1
PCZ8637	18.6	25.5	0.73	—	—	—	—	—	—
PCZ7645	19.0	27.2	0.7	17.5	24.6	0.71	54	4.8	0.5
A2031	21.0	27.0	0.78	17.0	24.0	0.71	57	5.3	2
A2032	21.0	28.0	0.75	—	—	—	—	—	—
PCZ7655	21.0	28.0	0.75	20.0	26.0	0.77	85	2.3	0.6
D1302a	21.0	26.0	0.81	17.0	22.0	0.77	55	7.3	1
PCZ7677	23.0	32.0	0.72	—	—	—	—	—	—
PCZ7407a	24.0	30.0	0.8	—	—	—	—	—	—
PCZ8631	24.0	32.0	0.75	22.0	28.0	0.79	83	4.8	1
109a	25.0	32.0	0.78	23.0	29.0	0.80	82	3.7	1
PCZ8635	25.0	35.0	0.71	25.0	34.0	0.73	65	1.5	1

Baculites vanhoepeni (cont.)

<i>Specimen</i>	<i>MxWb</i>	<i>MxWh</i>	<i>Wb/Wh</i>	<i>MnWb</i>	<i>MnWh</i>	<i>Wb/Wh</i>	<i>D</i>	<i>Ti</i>	<i>Tu/Wb</i>
Z1860	25.0	32.0	0.78	22.0	29.0	0.76	78	3.8	1
PCZ7635	25.0	35.0	0.71	—	—	—	—	—	—
A2034	25.0	33.0	0.76	24.0	32.0	0.75	55	1.8	1
A477	26.0	32.0	0.81	26.0	31.0	0.84	38	2.6	3
A2039	26.0	35.0	0.74	—	—	—	—	—	—
109b	27.0	35.0	0.77	—	—	—	—	—	—
Z1860	27.0	37.0	0.73	27.0	33.0	0.82	75	5.3	0.8
D1302b	27.0	32.0	0.84	24.0	26.0	0.97	45	13.3	2
Z1860b	27.0	35.0	0.77	26.0	36.0	0.72	51	1.9	2
Z1190b	28.0	35.0	0.8	25.0	34.0	0.73	87	1.2	0.5
PCZ8630	28.0	36.0	0.78	—	—	—	—	—	—
PCZ7417	28.0	36.0	0.78	28.0	34.0	0.82	58	3.4	1
PCZ7406	28.0	32.0	0.87	24.0	30.0	0.80	55	3.6	—
PCZ8638	31.0	42.0	0.74	—	—	—	—	—	—
A2029b	31.0	40.0	0.77	27.0	35.0	0.77	80	6.2	1
PCZ7411	32.0	43.0	0.74	—	—	—	—	—	—
Z1860d	32.0	38.0	0.84	—	—	—	—	—	—
PCZ7407b	37.0	46.0	0.80	—	—	—	—	—	—